NASA-SP-7003 (03)

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-7003 (03)

LUNAR SURFACE STUDIES

A CONTINUING BIBLIOGRAPHY

WITH INDEXES

A Selection of Annotated References to Unclassified Reports and Journal Articles introduced into the NASA Information System during the period February 1966–January, 1967.

Scientific and Technical Information Division
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. APRIL 1967

INTRODUCTION

With the publication of this third supplement, NASA SP-7003 (03), to the Continuing Bibliography on "Lunar Surface Studies" (SP-7003), the National Aeronautics and Space Administration continues its program of distributing selected references to reports and articles on aerospace subjects that are currently receiving intensive study. All references have been announced in either *Scientific and Technical Aerospace Reports (STAR) or International Aerospace Abstracts (IAA).* They are assembled in this bibliography to provide a reliable and convenient source of information for use by scientists and engineers who require this kind of specialized compilation. In order to assure that the distribution of this information will be sustained, Continuing Bibliographies are updated periodically through the publication of supplements which can be appended to the original issue.

The subject of Lunar Surface Studies is one which encompasses several scientific fields. As a consequence, this bibliography contains references to a variety of specific topics including the theory of lunar origin, the lunar atmosphere, and the physical characteristics of the body such as its topography, geology, cartography, and stratigraphy. Techniques of lunar observation, measurement, and analysis, e.g., photography, photometry, and spectrophotometry, are amply covered, and pertinent references to the instrumentation and equipment used in lunar investigation have also been included.

Each entry in the bibliography consists of a citation and an abstract. The listing of entries is arranged in two major groups. Report literature references are contained in the first group and are subdivided according to their year of announcement in *STAR*. The second group includes published literature references, subdivided according to their date of announcement in *IAA*. All reports and articles cited were introduced into the NASA information system during the period February, 1966–January 1967.

A subject index and a personal author index are included. These indexes use the Notation of Content (NOC), a one-sentence description of the contents of a document, rather than the title, to aid the user in locating pertinent entries.

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(continued)

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For further details please consult the *Introductions* to *STAR* and *IAA*, respectively.

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TYPICAL CITATION AND ABSTRACT FROM *STAR*

NASA SPONSORED DOCUMENT — **AVAILABLE ON MICROFICHE**

NASA ACCESSION NUMBER → **N67-10342*#** Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. ← **CORPORATE SOURCE**

TITLE → **A PHOTOMETRIC METHOD FOR DERIVING LUNAR TOPOGRAPHIC INFORMATION**

AUTHOR → T. Rindfleisch 15 Sep. 1965 20 p refs ← **PUBLICATION DATE**

CONTRACT OR GRANT → (Contract NAS7-100)

REPORT NUMBER → (NASA-CR-67718; JPL-TR-32-786) [CFSTI: HC $1.00/MF $0.50] ← **SALES AGENCY AND PRICE**; CSCL 22A ← **COSATI CODE**

A general and rigorous treatment is given of the photometric method for deriving lunar surface elevation information from pictures of the surface. In the course of the derivation certain shortcomings inherent in the method are pointed out. The resulting equations are then applied to the *Ranger* pictures as part of a digital processing procedure and examples are given.
Author

TYPICAL CITATION AND ABSTRACT FROM *IAA*

NASA SPONSORSHIP — **AVAILABLE ON MICROFICHE**

AIAA ACCESSION NUMBER → **A67-17336 * #**

TITLE → CONVECTIVE AND RADIATIVE HEAT TRANSFER DURING SUPER-ORBITAL ENTRY.

AUTHOR → H. Hoshizaki and K. H. Wilson (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Research Laboratories, Palo Alto, Calif.). ← **AUTHOR'S AFFILIATION**

(American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 3rd, New York, N.Y., Jan. 24-26, 1966, Paper 66-106.) ← **PREVIOUSLY ISSUED AS:**

TITLE OF PERIODICAL → AIAA Journal, vol. 5, Jan. 1967, p. 25-35. 30 refs. ← **PUBLICATION DATE**

Contract No. NAS 7-295. ← **CONTRACT, GRANT, OR SPONSORSHIP**

[For abstract see issue 07, page 1155, Accession no. A66-18459]

LUNAR SURFACE STUDIES

a continuing bibliography / with indexes APRIL 1967

1966

STAR ENTRIES

N66-15064*# Texas A&M Research Foundation, College Station. Activation Analysis Research Lab.
AN INVESTIGATION OF COMPUTER COUPLED AUTOMATIC ACTIVATION ANALYSIS AND REMOTE LUNAR ANALYSIS Quarterly Progress Report, Nov. 1962–1 Feb. 1963
Lloyd E. Fite, Edgar L. Steele, Richard E. Wainerdi, Edward Ibert, and Wayne Wilkins 1 Feb. 1963 74 p refs
(Grant NsG-256-62; Contract AT (40-1)-2671)
(NASA-CR-69215) CFSTI: HC $3.00/MF $0.75 CSCL 14B

The Mark II automatic activation analysis system is described, research in chemistry applications using this system is given, and a feasibility study is made of remote lunar analysis. A detailed description is given, in the form of an addendum, of the logic circuits governing the sequence of steps in the operations of the system. Topics considered are sample selection and the master control unit which is explained by a step-by-step analysis of a typical program cycle. In the chemistry applications area, count-test standard, silver, and selenium analyses were made. The silver analysis consists of studying the influence of radiation on ion migration in mice, and the selenium analysis consists of determining submicrogram quantities by radioactivation utilizing thermal neutrons and gamma ray spectroscopy. In the lunar study, a first generation remote activation analysis system is described, and results from the evaluation of simulated lunar samples are given. These samples were processed in a geometrical configuration similar to that expected on actual lunar exploration. C.T.C.

N66-15236*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE ORIGIN OF THE MOON
Paul D. Lowman, Jr. [1964] 16 p refs Submitted for Publication
(NASA-TM-X-56134) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Various studies attempting to shed light on the origin of the moon are discussed. Studies of the dynamical history of the Earth–Moon system, based on such verifiable quantities as changes in length of day, are considered promising; as is the study of lunar geology. Geological evidence on Earth which may have bearing on changes in the Moon's distance from the Earth; and geophysical discoveries, such as the Earth's non-equilibrium figure observed by Vanguard I, can also be applied to studies of the Moon's origin. M.W.R.

N66-15305*# Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.
EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Sixth Quarterly Progress Report, 1 Oct.–31 Dec. 1965
J. A. Ryan [1965] 30 p ref
(Contract NAS7-307)
(NASA-CR-69246) CFSTI: HC $2.00/MF $0.50 CSCL 22A

Progress is reported on several equipment modifications. These include the replacement of the mechanical forepump by sorption pumps, and the installation of a new experimental chamber which permits utilization of an electron gun and allows vacuum cleavage to be performed. Further, a device for vacuum cleaving was designed and built; and preliminary tests of this device in air indicated that it performed satisfactorily. The data obtained relate principally to the effects of the type of forepump, data repeatability, crystalline orientation effects, roughness effects, and surface damage and material transfer. It was found that: (1) The type of forepump used had no discernible effect on the data obtained. (2) The data appeared to be reasonably reproducible. (3) Crystalline orientation effects relatable to crystalline structure were present, but that further work would be required before a definite conclusion can be reached. (4) Decreasing surface roughness resulted in an increase in the magnitude of the low load adhesion, indicating that the dispersion forces were responsible for this adhesion. (5) Surface roughness was not responsible for surface damage and material transfer, thus strengthening the argument that these are produced through the action of the normal atomic bonding forces. R.R.D.

N66-15345*# California Univ., Berkeley. Space Sciences Lab.
INCREASED BRIGHTNESS OF THE LUNAR SURFACE
A. Palm and J. Koo 15 Jun. 1965 37 p refs *Its* Ser. No. 6, Issue No. 35
(Grant NsG-243-62)
(NASA-CR-69289) CFSTI: HC $2.00/MF $0.50 CSCL 20H

A number of mechanisms have been examined by which the enhanced solar radiation and flare protons could produce increases of the moon's brightness. The most plausible processes include direct luminescence, enhanced reflection in spectral regions characteristic of newly formed color centers, and indirect luminescence due to optical bleaching of these centers. However, the presumed solar energy flux intersecting the moon's orbit is not sufficiently intense for these processes to cause more than a fractional increase. Alternatively, the enhanced local brightness may have a solar origin. As more intense electromagnetic flux gives rise to a higher reflectivity in proportion to the color and intrinsic reflecting power of the surface material, existing color contrasts of the different lunar features become augmented. Author

N66-15364*# Martin Co., Baltimore, Md.
LUNAR ROCK CORING DEVICE DESIGN STUDY Final Report
Donald S. Crouch Oct. 1965 197 p refs
(Contract NAS9-3542)
(NASA-CR-65188; ER-13952) CFSTI: HC $5.00/MF $1.25 CSCL 13I

A study of rock coring techniques applicable for lunar surface operation within the constraints of early LEM missions resulted in the selection of a rotary-percussion system employing tungsten-carbide core bits. Fabrication of a breadboard model and subsequent evaluation tests demonstrated that 12 feet of consolidated rock core can be obtained without gaseous or liquid lubrication and hole flushing agents which are always employed with commercial drilling equipment. Parallel studies were conducted to the degree required for specifying the design and specifications for a coring device which can be operated in the lunar environment. Author

N66-15371*# Little, Arthur D., Inc., Cambridge, Mass. Research and Development Div.
THE EFFECT OF THE LUNAR ENVIRONMENT ON MAGMA GENERATION, MIGRATION, AND CRYSTALLIZATION, AUGUST 13, 1964–AUGUST 20, 1965
R. K. Mc Connell, R. V. Allen, J. Aronson, G. Feick, D. W. Lee et al 1 Nov. 1965 164 p refs
(Contract NAS9-3449)
(NASA-CR-65186) CFSTI: HC $5.00/MF $1.00 CSCL 03B

Studies of several models of lunar composition indicate that a period of intense volcanic activity with sudden onset and approximately exponential decline is entirely likely. A mechanism for sudden generation of magma is proposed on the basis of the thermal properties of a basalt-dunite mixture. Factors controlling the migration of magma through a dike, the formation of magma chambers and the deposition of volatile species on the moon's surface are discussed. Author

N66-15425*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LUNAR IMPACT CRATERS
Paul D. Lowman, Jr. [1964] 12 p Submitted for Publication
(NASA-TM-C-56115) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Selected lunar craters ascribed to impact are described, and two major classes are identified: primary craters, formed directly by bodies falling from space; and secondary craters, formed by ejecta from primary craters. Details are given on the topography and structure of Copernicus, and evidence that it is an impact crater is summarized. Main points include: (1) existence of large impact craters on earth; (2) independence of structural trends; (3) one-stage formation; (4) great size; and (5) similarity to terrestrial impact craters. A comparison is drawn between Eratosthenes and Copernicus, and the similarity found implies an impact origin for both. The older craters—Archimedes, Grimaldi, and Clavius—are also described, and the effect of major geological events on their structure are pointed out. Theories on an impact origin for the circular maria are also examined. Evidence for the origin of secondary impact craters includes the existence of similar features around terrestrial explosion craters, their gradational relationship with the ejecta blanket, and their association with rays. It was generally concluded that although much of the moon's surface is volcanic rock, most landforms are chiefly the direct or indirect result of meteoritic impact. M.G.J.

N66-15434*# Yale Univ., New Haven, Conn.
SOME CALCULATIONS PERTAINING TO THE FEASIBILITY OF MEASURING LUNAR HEAT FLOW Final Report
Sydney P. Clark, Jr. Sep. 1965 58 p refs
(Grant NsG-400)
(NASA-CR-69267) CFSTI: HC $3.00/MF $0.50 CSCL 20M

Study of the steady periodic temperatures in the lunar material will give usable information only if the surface material alone has an appreciable effect on the amplitude and phase of the thermal wave. Layering tends to reduce the amplitude of the fluctuation at a given depth. High-amplitude fluctuations near a place where the poorly conducting surface layer is missing do not penetrate far and pose no difficulty. Large perturbations of heat flow may be caused by irregularities in thickness of the surface layer, and a number of closely space measurements at a given landing site will be required to minimize this source of error. The "blanket" method of measuring lunar heat flow is not considered feasible because of the necessity of very closely matching the local albedo with the blanket, and because a blanket with properties such that an easily measured gradient free from periodic fluctuations can be set up by the lunar flux requires a prohibitively long time to come to thermal equilibrium. Conversely a blanket with a suitable time constant will yield only a small, seriously disturbed gradient that will be difficult to measure. Author

N66-15601# Illinois Univ., Urbana. Electrical Engineering Research Lab.
IONOSPHERIC RESEARCH Seventh Quarterly Progress Report, 1 Apr.–30 Jun. 1965
H. D. Webb [1965] 107 p refs
(Contract DA-36-039-ANC-03703(E))
(Rept.-7; AD-623259) CFSTI: HC $4.00/MF $0.75

The object of the ionospheric research is to collect data by receiving signals by reflection from the moon and measuring the Faraday Rotation; to use the data to calculate the electron content of the ionosphere above the earth; to study the diurnal, seasonal, and irregular changes in electron content; to correlate irregular changes in electron content with other natural phenomena; and to study the reflecting surface of the moon. TAB

N66-15700# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
INTERNAL STRUCTURE OF THE MOON
Zdenek Kopal Sep. 1965 218 p refs *Its* Mathematical Note No. 426
(DI-82-0466; AD-624047) CFSTI: HC $6.00/MF $1.25

The internal structure of the moon and its evolution are discussed. Some topics considered are: hydrostatic equilibrium; thermal history of the moon; stress history of the moon; possible convection in lunar interior; chemical composition of the moon; lunar exosphere. TAB

N66-15854# Manchester Univ. (England). Dept. of Astronomy.
SPECTROPHOTOMETRIC STUDY OF THE LUNAR SURFACE Final Scientific Report
Zdenek Kopal Jul. 1965 27 p refs
(Contract AF 61(052)-378)
(AFCRL-65-772; AD-623871) CFSTI: HC $2.00/MF $0.50

The report gives an account of the instrumentation (photoelectric spectrometers) built for the study of the luminescence of the lunar surface, as well as of the observations carried out with their aid. The existence of a transient luminescence has

repeatedly been detected photoelectrically by the "line-of-depth" method, as well as photographically by use of narrow-passband interference filters in different parts of the lunar surface. The present report gives a summarizing account of such observations. It is pointed out that luminescence is connected with the solar activity, and induced probably by the corpuscular output of solar flares. Author

N66-16166*# Minnesota Univ., Minneapolis. "TYCHO" Study Group.
REPORT OF AUGUST 1965 "TYCHO" MEETING
Aug. 1965 396 p refs Meeting held in Boulder, Colo.
(Contract NSR-24-005-047)
(NASA-CR-69878; TG-1) CFSTI: HC $7.00/MF $2.00 CSCL 03B

CONTENTS:

N66-16167* Princeton Univ., N. J.
INTERNAL TEMPERATURES OF THE MOON
Robert A. Phinney and Don Lynn Anderson (Calif. Inst. of Tech.) *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 71 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-2)

Thermal history calculations are made to investigate melting in the interior of the Moon and volcanism. Various models are used to predict the start of melting, and it shown that differentiation and volcanism, accompanying this melting, will tend to redistribute both heat and matter. After differentiation, the increased concentration of radioactivity makes the near surface of the Moon heat up very rapidly. Volcanism probably occurred two to three billion years ago, following the differentiation. The Moon is probably a differentiated body, but without a heavy core; and the internal layering is probably silicic. It is concluded that lava and/or ash flow is probably present on the lunar surface. Mars, on the other hand, is shown to be an undifferentiated body which will not melt. Evidence points to the possibility of considerable seismicity on the Moon, and specific first generation experiments are suggested to determine if this condition will be a threat to manned space missions. M.W.R.

N66-16168* Minnesota Univ., Minneapolis.
EROSION OF THE LUNAR SURFACE BY METEOR IMPACT
Robert J. Collins *In its* Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 16 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-3)

The bombardment of the lunar surface by meteorites will produce craters. The flux of these meteors on the Earth is reported for the range 10^8 to 10^{-14} grams. Correlation of this flux with the experimental effects produced by the impact of hypervelocity particles with solid surfaces allows a prediction of the impact produced crater distribution on the lunar surface. The present report shows that in craters of small size ($d \leq 300$ m) steady state has been reached in coverage. It is suggested that the observed crater distribution is primarily the result of meteor infall. Author

N66-16169* Lincoln Lab., Mass. Inst. of Tech., Lexington.
RADAR STUDIES OF THE MOON
John V. Evans *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 81 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-4)

Radar experiments are described which shed light on the composition of the moon. Based on a two-layer model, it appears that at normal incidence some 60% of the echo energy is reflected from within the surface, presumably at points where the density increases rapidly with depth. The dielectric constant of the upper layer is considered to be not less than 1.8, which implies a porosity range between 70 and 90% depending upon the nature of the material. It is concluded that the depth of the upper layer must be greater than 23 cm, but also irregular. Under the assumption that there is only a single reflecting layer within the surface, the base layer must be highly compacted if not solid; and dielectric constant of this layer is estimated to be between 4.5 and 5.0. Range doppler mapping with controlled polarization at a number of wavelengths is considered to be the only ground-based technique for further exploring the base layer of the moon. M.W.R.

N66-16170* Cornell Univ., Ithaca, N. Y.
PART I: THE CASE AGAINST VOLCANISM. PART II: A RECOMMENDATION FOR PHOTOGRAPHY ON THE MOON'S SURFACE
Thomas Gold *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 20 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-5)

The presence of ice below and the depth of the dust layer above the lunar surface is discussed in a paper which presents the case against volcanism on the Moon. Since the mean density of the Moon is estimated to be slightly less than the uncompressed density of the Earth, it is speculated that the Moon was formed at a lower temperature and from a greater proportion of more volatile light elements, with water among the most plausible constituents. The water does not reach the lunar surface, which is usually well below freezing, because any water going upward is frozen in surface cracks. It is considered well worth investigating, however, whether the small quantities of water vapor escaping from the Moon might correspond to the slight evaporation from the top of the underlaying ice. There are numerous convex structures on the Moon's surface, both inside craters and around edges of maria; these resemble terrestrial pingos, perma-frost ice lenses in the ground which heave up the underlying material. It is speculated that deposits of dust layers in some parts of the lunar surface must be very deep due to erosion of material on the highlands. A recommendation is offered for photography, including design of a camera, of the Moon's surface.
M.W.R.

N66-16171* Stanford Univ., Calif.
LEVITATION OF DUST ON THE SURFACE OF THE MOON
Hubert Heffner *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 18 p refs (See N66-16166 07-30)
CFSTI: $7.00/MF $2.00
(TG-6)

Dust particles cannot be raised from the surface of the moon by photoelectric space charges, but submicron dust particles can be suspended if they are raised to a sufficient height by micrometeorite impact. An appreciable proportion of these particles will remain suspended as long as the angle to incidence of solar radiation is not too low. It is shown that particles tend to migrate toward the shadow region due to the horizontal component of radiation pressure. Charged dust particles may be a nuisance as well as a danger to an astronaut, particularly if he falls. During the daylight hours, the astronaut's suit will charge positively due to the photoelectric effect, and thereby repel the suspended particles which are also positively charged. If he should fall, however, he would encounter a layer of particles approximately half of which are negatively charged. Attempts to wipe off these dust coatings will be largely ineffective and will increase electrostatic charge. Experiments under vacuum conditions are recommended to obtain data about electrostatic attraction of dust.
M.W.R.

N66-16172* Stanford Univ., Calif.
THE POTENTIAL AND ELECTRIC FIELD AT THE SURFACE OF THE MOON
Hubert Heffner *In* Minn. Univ. Rept. of Aug. 1965 "Tycho" Meeting Aug. 1965 18 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-7)

During the lunar day, the surface of the Moon charges to a positive potential due to the photoelectric emission of electrons from its surface. Using the assumptions for solar photon flux below 4000 Å

$$N_\nu = 2 \times 10^{16} \ \frac{\text{photons}}{\text{cm}^2\,\text{sec}}$$

for quantum efficiency ($\eta = 10^{-3}$) and for the temperature of the photoelectrons

$$\frac{kT_p}{e} = 3 \text{ volts}$$

employed here, we find the potential of the Moon to be approximately 30 volts when the Sun's radiation has normal incidence. The Moon is surrounded by a space charge layer extending outward some eight meters. The electric field at the Moon's surface, under conditions of normal incidence of solar radiation, is approximately 1.6 volts/cm. Somewhat more realistic values for the photoelectron flux ($\eta N_\nu = 2 \times 10^{11}$), two orders of magnitude less than the value first assumed, yield a surface field of 0.16 volts/cm, a potential of 18 volts, and virtually the same value for the extent of the space charge layer.
Author

N66-16173* Princeton Univ., N. J.
INTERPRETATION OF THE BRIGHTNESS AND POLARIZATION CURVES OF THE MOON
John J. Hopfield *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 26 p refs (See N66-16166 07-30)
CFSTI: HC $7.00/MF $2.00
(TG-8)

Theoretical models are presented for lunar brightness at small phase angles for an underdense surface and the polarization of moonlight. Brightness versus phase angle is discussed; as is the problem of comparing lunar observations, theory, and experiments made on simulated lunar surfaces. Shadow is considered in terms of the lunation cusp and negative polarization.
M.W.R.

N66-16174* Massachusetts Inst. of Tech., Cambridge.
ELECTROMAGNETIC AND THERMAL PROPERTIES OF THE MOON'S SURFACE
Benjamin Lax *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 19 p refs (See N66-16166 07-30)
CFSTI: HC $7.00/MF $2.00
(TG-9)

Radar reflection has provided an estimate of the dielectric constant k of the Moon's surface to depths of meters. The value of k = 2.6 corresponds to a porosity of ≈ 70% and a density $\rho \approx 1.0$ gm/cm^3. Thermal measurements at infrared of the lunation and eclipses yield values of the thermal inertia $(K\rho C)^{-1/2} \approx 750$. Since C = 0.2 cal/cm sec deg. the thermal conductivity is estimated to be $K \approx 8.5 \times 10^{-6}$ cal/cm sec deg C. From radiometric measurements at microwave and millimeter frequencies the ratio of the thermal and electrical conductivities are determined. This yields an electrical conductivity $\sigma \approx 4.3 \times 10^{-5}$ mho-cm^{-1} corresponding to a loss tangent of σ/ω^{ϵ} $\approx 3 \times 10^{-3}$. Bearing strength can be estimated from the density and the thermal inertia when correlated with laboratory measurements of porous and powdered rocks of many varieties. If the estimate is made conservatively to correspond to powdered rock, then the bearing strength is approximately 75 lbs/sq ft.
Author

N66-16175* Minnesota Univ., Minneapolis. Dept. of Physics.
THE EVIDENCE FOR A PARTICULATE MATTER IN SPACE AND ITS POTENTIAL ACCRETION RATE BY THE MOON AND THE EARTH
Edward P. Ney *In its* Rept. of Aug. 1965 "Tycho" Meeting Aug. 1965 26 p (See N66-16166 07-30) HC $7.00/MF $2.00
(TG-10)

Sources of information about the interplanetary dust are examined. It is shown that the observations on the zodiacal light and the direct observation of particles near the Earth may be made compatible with the Earth collecting dust about 10^4 the volume traced out by the Earth. The infall of dust to the Earth corresponds to an increase in the Earth's radius of

about three centimeters per million years. It is estimated that the corresponding figure for the Moon will not exceed about 30 Å per year. To account for lunar erosion, the incoming material would have to stir up more than 100 times its own mass of lunar surface. Author

N66-16176* Minnesota Univ., Minneapolis.
MECHANISMS FOR LUNAR LUMINESCENCE
Edward P. Ney, N. J. Woolf (Princeton Univ.), and Robert J. Collins *In its* Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 26 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-11)

The visibility of luminescence on the Moon depends on the competing processes that illuminate the Moon and that provide energy for luminescence. It is shown that the most favorable times for seeming luminescence are at new Moon on the far side and during rare dark eclipses. The luminosity and color of these rare eclipses is explained. Observations supposedly of luminescence during lunar day are criticized, and only the spectroscopic evidence is taken to support the reality of luminescence. Both direct and storage processes have been considered for converting energy to luminescence. Direct processes in lunar day cannot be energized by presently known sources of particles. If indirect processes occur they may give information about the dust particles at the extreme lunar surface. Author

N66-16177* Princeton Univ., N. J.
STRUCTURE OF THE LUNAR DUST LAYER
Roman Smoluchowski *In* Minn. Univ. Rept. of Aug. 1965 "TYCHO" Meeting Aug. 1965 16 p refs (See N66-16166 07-30) CFSTI: HC $7.00/MF $2.00
(TG-12)

Experiments show that corpuscular radiation such as solar wind can sinter fine dust by producing displaced atoms which diffuse towards the surface of the grain. The estimated rate of churning of the topmost layer of lunar dust excludes sintering through sputtering. It follows that the dust is probably not loose but is partly coherent (0.5 dyne per particle), which increases its mechanical strength and decreases its mobility. Lower layers of dust are compacted by meteoritic bombardment and a close packed density may be reached at a depth of about a meter. Loads which will not sink in loose and in sintered dust are calculated. Author

N66-16319# Joint Publications Research Service, Washington, D. C.
ON THE INAPPLICABILITY OF BALDWIN'S CORRELATION TO THE DETERMINATION OF THE CAUSES OF THE FORMATION OF LUNAR CRATERS
G. S. Shteynberg 26 Jan. 1966 10 p refs Transl. into ENGLISH from Dokl. Akad. Nauk (Moscow), v. 165, no. 1 p 55–57
(JPRS-33897; TT-66-30340) CFSTI: $1.00

Relationships established by R. B. Baldwin which support the meteorite hypothesis for the formation of lunar craters are discussed. The Baldwin theory states that for craters caused by bombs or by shells, terrestrial meteorite craters, and lunar craters the relationship between the diameter of the crater and, respectively, the depth of the bottom, height of the ridge, and energy of the explosion constitute a single sequence. Baldwin's conclusions were accepted by the advocates of the meteorite hypothesis, in spite of the fact that they indicate only the explosive nature of the formation of craters. In this report the author attempts to show the inapplicability of Baldwin's correlation by explaining that even though lunar craters satisfy the relationships established for explosion craters it does not follow that their origin was derived from meteorites, since for volcanic objects these relationships are also valid. It is concluded that different criteria are needed to refer lunar craters to meteorites or volcanic types. M.R.W.

N66-16389*# Bendix Corp., Ann Arbor, Mich. Bendix Systems Div.
LUNAR NAVIGATION STUDY, SECTIONS 8 THROUGH 10 AND APPENDICES Final Report, Jun. 1964–May 1965
L. J. Abbeduto, M. E. Amdursky, D. K. Breseke, J. T. Broadbent, R. A. Gill et al Jun. 1965 414 p refs
(Contract NAS8-11292)
(NASA-CR-68285; BSR-1134, Sec. 8–10, Append.) CFSTI: HC $7.00/MF $2.00 CSCL 22C

Summarized are the results on lunar navigation concept studies, their component capabilities, and component requirements. The objective of the analysis was the accumulation of data such that application of the resultant curves will lead to a design point system dependent upon the set of traverse ranges, mission duration, and terminal requirements. The navigation error of each investigated concept is listed in a table. Distance sensing devices, comprised of odometers, accelerometers, and Doppler radar subconcepts evolved as principle component error sources. G.G.

N66-17387 National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
LUNAR SURFACE AND FREE SPACE HAZARDS RELATING TO SPACE SUIT DESIGN
Jerry R. Goodman and Matthew I. Radnofsky *In* Chrysler Corp. A Collection of Papers on Spacesuits and Human Performance 16 Aug. 1965 25 p Presented at Human Factors Session, Ann. Inst. of Environ. Sci. Tech. Meeting, 22 Apr. 1965 (See N66-17386 08-05)

Anticipated lunar environmental conditions and effects on man are discussed along with how the Apollo Extravehicular Mobility Unit (EMU) allows man to perform under these conditions. The EMU provides protection by encapsulating the astronaut in a liquid-cooling anthropomorphous pressure vessel, the Pressure Garment Assembly (PGA), with 3.7 psia oxygen. A Portable Life Support System (PLSS) is carried on the astronaut's back and provides for PGA pressurization and oxygen supply, CO_2 removal, liquid and oxygen temperature control, telemetry of critical medical parameters, suit pressure and high oxygen flow sensing, and extravehicular communications. There is an auxiliary oxygen supply which is separated from the PLSS. A thermal-meteoroid garment will protect the PGA from the high velocity primary and secondary meteoroid particle environment, limit heat flux in and out of the EMU, and prevent local hot or cold spots during the short term contact with the lunar surface. M.W.R.

N66-17399# Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.
GEO-ASTROPHYSICS LABORATORY REVIEW, JANUARY–JUNE 1965
John C. Noyes et al [1965] 35 p refs

Reviews are presented for research projects related to the physical environment of the atmosphere of the Earth and other parts of the solar system. Analysis of data obtained during a lunar eclipse indicates many hundreds of localized regions on the Moon's surface which cool less rapidly than their surroundings. Thermal enhancements were found in extended areas of some maria. Another study sheds light on the anomalous cooling characteristics of certain lunar features.

The transport of charged particles in disordered magnetic fields was studied, as was the decay of postulated solar neutrons and the subsequent transport of the decay protons. Experimental work is reported in the fields of radio star scintillations, geomagnetic micropulsations, microwave scattering by random media, very low frequency whistler mode echoes, and cosmic ray neutrons. M.W.R.

N66-17461# Library of Congress, Washington, D. C. Aerospace Technology Div.
FOREIGN SCIENCE BULLETIN, VOLUME 2, NUMBER 1
Jan. 1966 97 p refs Sponosored in part by DOD
CONTENTS:

N66-17465 Library of Congress, Washington, D. C. Aerospace Technology Div.
THE LUNAR SURFACE
V. Mutschall *In its* Foreign Sci. Bull., Vol. 2, No. 1 Jan. 1966 p 50–55 refs (See N66-17461 08-34)

Soviet papers are reviewed in which various ideas concerning the nature of the lunar surface and subsurface, i.e., features, materials, properties, and characteristics, are set forth. Much of the work has been directed toward problems upon whose solution will depend the safety of the astronauts who land there. It is pointed out that, while some of the ideas expressed are contradictory and some are not directly related to the question at hand, they are included here because of their broad implications for future research. D.T.

N66-17476*# Minnesota Univ., Minneapolis. Dept. of Electrical Engineering.
"TYCHO" STUDY GROUP Final Report
15 Dec. 1965 45 p
(Contract NSR-24-005-047)
(NASA-CR-70458) CFSTI: HC $2.00/MF $0.50 CSCL 22A

Conclusions and recommendations are presented for a study of the lunar surface. Also presented are aspects and comments on present knowledge in this area. A major conclusion is that remote sensing of the unfamiliar terrain will not enable an accurate prediction of bearing strength to be made. This difficulty is a direct result of the fact that the interaction of electromagnetic radiation with the lunar surface does not sense those collective effects that play a role in mechanical bonding of structures. Recommendations are for additional earth space laboratory experiments, additional examination of data already on file, and possible experiments which would further aid in describing the nature of the surface of the moon. C.T.C.

N66-18388*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
AN EXPLANATION OF TEKTITE CHEMISTRY IN TERMS OF LUNAR ASH FLOWS
John A. O'Keefe and Ernst W. Adams [1964] 38 p refs Submitted for Publication
(NASA-TM-X-56128) CFSTI: HC $2.00/MF $0.50 CSCL 03B

Theoretical calculations of pressure, temperature, and voidage (fraction of the volume not occupied by solid matter) are made for the dense phase (bulk density 0.5 to 1.0 gm/cm^3) of an ash flow, assuming a steady state, uniform temperature, and steady emission of gas from the solid matter. The problem reduces to an ordinary non-linear differential equation of the first order; the solution is presented in non-dimensional variables, together with homology relationships for the physical parameters. For a constant model, the required gas emissivity is found to vary inversely with the square of the gravity. Author

N66-18441*# Yale Univ., New Haven, Conn. School of Medicine.
[CONDUCT RESEARCH ON GAS CHROMATOGRAPHIC SYSTEMS TO ANALYZE CERTAIN CHEMICAL CONSTITUENTS OF THE SURFACE OF THE MOON] Progress Report, 1 Jul.–31 Dec. 1965
S. R. Lipsky 25 Feb. 1966 4 p
(Grant NsG-192)
(NASA-CR-70849) CFSTI: HC $1.00/MF $0.50 CSCL 14B

A fast scan high resolution mass spectrometer system was developed for use in conjunction with gas chromatography instrumentation. Preliminary results indicate that the system has the capability of rapid high resolution scanning, permitting a chromatographic peak to be scanned in 6 to 10 seconds with a resolving power of at least 1 in 10,000, covering a decade in mass. Other advantages include rapid retrieval of data, automatic switching from high to low resolution mode during a chromatographic analysis, and rapid high resolution scans on relatively nonvolatile samples introduced into the ion source by a direct insertion probe. The interfacing with a molecular separator is identified as another important facet of the mass spectrometer–gas chromatograph tandem operation. M.G.J.

N66-18666*# National Aeronautics and Space Administration, Washington, D. C.
APOLLO LUNAR SCIENCE PROGRAM, REPORT OF PLANNING TEAMS. PART II: APPENDIX

Dec. 1964 210 p refs
(NASA-TM-X-57274) CFSTI: HC $6.00/MF $1.25 CSCL 22A

CONTENTS:

N66-18667* National Aeronautics and Space Administration, Washington, D. C.
PROJECT APOLLO GEOLOGICAL FIELD INVESTIGATIONS
Edward N. Goddard, J. Hoover Mackin, E. M. Shoemaker, and Aaron C. Waters *In its* Apollo Lunar Sci. Program, Rept. of Planning Teams. Part II: Appendix Dec. 1964 28 p (See N66-18666 09-30) CFSTI: HC $6.00/MF $1.25

Objectives of geological field investigations in the Apollo scientific program are to obtain complete and accurate knowledge of the nature and structure of the lunar surface and to determine the regional stratigraphic and petrologic character of the Moon at various landing sites. It appears highly likely that the Moon's surface is covered with a layer of finely-broken rock fragments; thickness of the layer, size distribution of the rock fragments, and size and spacing of the superimposed craters have to be determined. Both sampling and in situ measurements of physical and engineering properties of lunar surface materials are advocated. Astronauts should be familiar with geological methods and able to handle the following equipment: (1) Jacob's staff sampling devices; (2) audio system and recorder; (3) lightweight geologist's pick, magnifying lens, and marking tool; and (4) sample collecting equipment. G.G.

N66-18668* National Aeronautics and Space Administration, Washington, D. C.
SAMPLING AND EXAMINATION OF LUNAR SURFACE MATERIALS Preliminary Report
Eugene N. Cameron (Wisconsin Univ.), Edward C. T. Chao (Geological Survey), Clifford Frondel (Harvard Univ.), and Harry H. Hess (Princeton Univ.) *In its* Apollo Lunar Sci. Program, Rept. of Planning Teams. Part II: Appendix Dec. 1964 12 p (See N66-18666 09-30) CFSTI: HC $6.00/MF $1.25

A guideline for sampling, packaging, transportation, and preparation of lunar rock surface materials is presented. Preliminary examination of the samples will consist of bacteriological evaluation, possible interactions of the sample constituents with the terrestrial environment, measurements of its physical properties, and a description of their minerology, petrography, and physical nature. Detailed geological examinations will include quantitative chemical analyses; X-ray and morphological crystallographical descriptions; physical evaluation of crystal phases; petrographic descriptions of solid aggregates; studies of phase transformations and equilibrium; and exposure to terrestrial environmental conditions. G.G.

N66-18669* National Aeronautics and Space Administration, Washington, D. C.
GEOCHEMISTRY PLANNING TEAM First Report
In its Apollo Lunar Sci. Program, Rept. of Planning Teams. Part II: Appendix Dec. 1964 30 p (See N66-18666 09-30) CFSTI: HC $6.00/MF $1.25

The geochemical portion of the Apollo science program is discussed and a proposed schedule of experiments for lunar samples is outlined. Early experiments should be confined to those (1) where information will be lost by waiting, or (2) which can yield preliminary data useful for planning later experiments. A part of the sample should be set aside as reserve for the distant future. First stage experiments include gamma ray spectra, sensitive structural studies, and gas determinations. Later experiments will be micro- and semimicroanalyses, X-ray fluorescence for major constituents, electron microprobes, quantitative spectrographic analyses, and neutron activation analyses. G.G.

N66-18672* National Aeronautics and Space Administration, Washington, D. C.
LUNAR GRAVITY MEASUREMENTS
J. Weber and G. J. F. Mac Donald *In its* Apollo Lunar Sci. Program, Rept. of Planning Teams. Part II: Appendix Dec. 1964 10 p refs (See N66-18666 09-30) CFSTI: HC $6.00/MF $1.25

Precise measurements of the acceleration due to gravity on the lunar surface over a period of months may yield valuable information concerning the internal constitution of the moon. The moon will interact with gravitational radiation. The lunar free oscillations may be observed to be excited by such radiation if the power spectrum is sufficiently intense over the frequencies of certain of the moon's normal modes. Simultaneous observation of the earth's normal mode excitation will make it very likely that the effects are due to gravitational waves. Observations are planned using a lunar gravimeter having a weight less than 30 pounds, a volume less than one cubic foot, power consumption less than 5 watts continuously, and less than 15 watts with 30% duty cycle. This device will continuously monitor the lunar gravitational field, recording changes greater than about one part in 10^9. Author

N66-19182# Joint Publications Research Service, Washington, D. C.
PROBLEMS OF SEISMIC STUDIES ON THE MOON
V. N. Zharkov 16 Feb. 1966 21 p Transl. into ENGLISH from Zemlya i Vselennaya (Moscow), no. 6, Nov.–Dec. 1965 p 16–23
(JPRS-34142; TT-66-30584) CFSTI: $1.00

Selenological characteristics of the moon are reviewed, and a moon model is discussed. Theoretical data are given for pressure and density distributions, gravitational acceleration, and heat flux in the interior. Possible modes of seismic wave propagation and possible results are considered. The complexity of lunar seismic study is indicated to lie in delivering the instrument to the moon, placing it, and transmitting the data to the earth. N.E.N.

N66-19648*# Bellcomm, Inc., Washington, D. C.
PHOTOMETRY AND POLARIMETRY OF THE MOON AND THEIR RELATIONSHIP TO PHYSICAL PROPERTIES OF THE LUNAR SURFACE
C. A. Pearse 23 Aug. 1963 91 p refs
(NASA-CR-70713) CFSTI: HC $3.00/MF $0.75 CSCL 03B

A review is given of experimental and theoretical information relating to the photometry of the moon. An attempt is made to display the salient lunar light reflecting properties which are controlled by the exact nature of the lunar surface microrelief. A brief discussion is presented of a model of the lunar surface covering layer, and this model is compared with the conclusions necessitated by photometric data. A listing is made of factors excluded from the study, and conclusions and recommendations are given. C.T.C.

N66-19836 Radio Corp. of America, Princeton, N. J. Developmental Cameras.
A PROPOSED STEREOSCOPIC TV OBSERVATION SYSTEM FOR A LUNAR ORBITER
F. J. Bingley *In its* Space Electron. [1965] p 40-45 Presented at the SMPTE Tech. Conf., New York, 28 Sep. 1964 (See N66-19827 10-31)

This camera system has been proposed for use on the Surveyor orbiter spacecraft. To provide information concerning the topography of the lunar surface, the camera system provides stereoscopic pairs of images. Methods of achieving stereoscopy at the desired resolution of 10 meters of lunar surface are discussed. The relation between orbital parameters, and the extent of lunar surface surveyed is considered in relation to available sensor resolution. The optical system requirements are described in terms of aperture and focal length necessary to perform the mission under the conditions of illumination, lunar albedo, resolution, and signal-to-noise ratio. Author

N66-20584# Lockheed-California Co., Burbank.
SELENODETIC MEASUREMENTS AND ERROR ANALYSES OF TWO LOCKHEED ANNULAR ECLIPSE EXPEDITIONS TO AFRICA Final Report, 1 Jun. 1964–31 May 1965
Laurence G. Stoddard, Donald G. Carson, and John S. Fritzen Jan. 1966 107 p refs
(Contract AF 19(628)-4162)
(LR-18858; AFCRL-65-532; AD-627064) CFSTI: HC $4.00/MF $0.75

The methods used to obtain and analyze the results of two annular eclipses in Africa by Lockheed USAF expeditions are described. Comparison is made with University of Manchester results and Watts Atlas of the Marginal Zone of the moon. The 1962 July 31 eclipse agrees well with Watts for local irregularities but does contain a discrepancy. The 1963 January 25 shows good correlation with the same discrepancy. A description of the expeditions and recommendations for future work is also made in this report. Author(TAB)

N66-20989*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
PHOTOMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES Quarterly Progress Report No. 2, 1 Oct.–31 Dec. 1965
J. D. Halajian and F. A. Spagnolo Jan. 1966 104 p refs
(Contract NAS9-3182)
(NASA-CR-65263; RM-308) CFSTI: HC $4.00/MF $0.75 CSCL 07D

Consideration is given to spectral photometry, photometry, of suspended particles, and the geometry of backscattering surfaces in a study on photometric measurements of simulated lunar surfaces. In the spectral photometry area it is reported that albedo and photometric measurements of all natural specimens at specified viewing angles and wavelengths were completed. Spectral responses of the photometric system and the sun-sensor systems used in lunar observations are discussed. A preliminary comparison of test results with available lunar data reveals certain similarities in albedo versus color behavior, and in the "opposition" region of the brightness-phase angle curve. In the second area, photometric properties of suspended particles were measured at various particle spacing to diameter ratios. Relative to the geometry of backscattering surfaces, a computer program designed to determine the closest photometric match of the lunar surface with four contrived geometries under a wide range of boundary conditions was completed. Results confirm previous qualitative analyses, and imply that good quantitative estimates may be obtained of the porosity of the uppermost optical layer of the lunar surface. C.T.C.

N66-20995*# Texas Instruments, Inc., Dallas. Science Services Div.
STUDY OF QUANTITATIVE METHODS FOR LEM LANDING-SITE SELECTION Final Report
15 Mar. 1966 242 p refs
(Contract NAS9-3418)
(NASA-CR-65272) CFSTI: HC $6.00/MF $1.50 CSCL 14E

Mathematical, statistical, and optical-Fourier methods were developed for prediction of LEM landing safety against excessive slope and protuberance hazards. Systems utilizing data in elevation matrix, contour map, and photographic formats were considered. Detailed treatments based on elevation matrix data offer more promise than those involving contour maps because of physical handling problems and mechanization difficulties associated with the latter. Optical-Fourier techniques appear feasible for rapid comparison of gross regional features, but further development is required to attain operational status. In order to make certification measurements with 90 percent confidence in required accuracy, it was determined that improvements in the contemplated Orbiter camera system resolution and viewing geometry are required. Alternately, increased reliance must be placed on slope and protuberance measurements derived from Ranger and Surveyor photographs in conjunction with statistical estimates. Author

N66-21161# Centre National de Recherches de l'Espace, Brussels (Belgium).
BIBLIOGRAPHY. II: INTERPLANETARY SPACE [BIBLIOGRAPHIE. II: ESPACE INTERPLANETAIRE]
[1964] 128 p refs *Its* Publ. no. 3a
CFSTI: HC $4.00/MF $1.00

An interplanetary space bibliography is presented that contains numerous publications on Moon and Venus, as well as some studies on space plasmas, galaxies, stellar X-ray emission, etc. G.G.

N66-21180# Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.
LOW FREQUENCY RADIO ASTRONOMY EXPERIMENTS IN SPACE
N. Frank Six, Jr. Feb. 1966 39 p refs
(R-180)

Radio astronomical observations made from the surface of the Earth are restricted at the high frequency end of the RF spectrum by the troposphere and at the low frequency end by the ionosphere. Artificial Earth satellites provide the means for eliminating these restrictions, but low frequency studies require large antennas, so a large stable platform is desirable. The surface of the Moon meets this requirement. In order to study the sources (Sun, Jupiter, radio stars, cosmic background, and perhaps Earth and Saturn) over the frequency range from 30 kHz to 10 MHz, the radiometer should be able to measure intensity, apparent position, apparent size, temporal variation, and polarization. The order of experiments will most likely be determined by the antenna system complexity and size. Early experiments on the lunar surface probably will employ simple broadband "pencil-beam" antennas. Man will be necessary for antenna installation and initial calibration. Author

N66-21350*# Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART A: LUNAR AND PLANETARY INVESTIGATIONS Annual Progress Report No. 6, 1 Jul. 1964–1 Jul. 1965
Nov. 1965 131 p refs
(NASA Order R-66)
(NASA-CR-71414) CFSTI: HC $4.00/MF $1.00 CSCL 03B

Astrogeologic studies are being conducted to determine and map the stratigraphy and structure of the lunar crust, to determine the sequence of events that led to the present condition of the lunar surface, and to determine the processes by which these events took place. This report contains the preliminary results of detailed geologic mapping of 15 new quadrangles on a scale of 1:1,000,000. The equatorial belt of the moon (32° N–32° S, 70° E–70° W) has now been completely mapped. Results of new mapping and of detailed studies of previously defined stratigraphic units are included. Photometric and polarimetric studies to supplement the mapping program are also presented. R.N.A.

N66-21352*# Boston Univ., Mass.
AN INVESTIGATION OF SCHROTER'S RULE Research Report No. 17
William J. Abrams Jan. 1966 20 p refs
(Grant NsG-246-62)
(NASA-CR-71416) CFSTI: HC $1.00/MF $0.50 CSCL 03B

The validity of using Schroter's Rule to evaluate theories of lunar crater formation is investigated. This rule states that the volume of material in the rim of a lunar crater is roughly equal to the volume of the depression formed below the surrounding ground level. A criterion was established to distinguish crater volume from rim volume, and to define the outer limits of the rim extension from the crater center. Values of rim volume, crater volume, ratio of rim volume to crater volume, and the probable error in the ratio were obtained for 39 lunar craters. Results show huge uncertainties in volume ratios generated by a seemingly small probable altitude error of 100 meters. This indicates that any statements concerning the ratio of rim volume to crater volume using less accurate means than those used in this study to obtain data are likely to be invalid, and that Schroter's Rule does not hold for the craters tested in this study. R.N.A.

N66-21584*# Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART B: CRATER INVESTIGATIONS Annual Progress Report, 1 Jul. 1964–1 Jul. 1965
H. G. Wilshire et al Oct. 1965 184 p refs
(NASA Order R-66)
(NASA-CR-71420) CFSTI: HC $5.00/MF $1.00 CSCL 08G

Results of field investigations and laboratory studies of volcanic, explosive, and impact events and other aspects of crater phenomenology are summarized in connection with a long-term astrogeological program to determine the structure and origin of the Moon's crust. Structures and other aspects of three naturally formed terrestrial craters, in Australia, Tennessee, and Texas, are discussed. Mercury distribution in shocked and unshocked rocks at the Odessa meteorite craters in Texas is detailed, along with (1) the possible origin of pseudotachylite from Archean granite of the Vredefort dome in Africa and (2) the geology of a large body of granite in Colorado that is being considered as a site for conducting high-explosive cratering experiments in hard, polymineralic rocks. The Moses Rock diatreme in Utah and its similarity to rilles on the lunar surface is reported. Two experimental impact studies deal with (1) impact of craters formed in water-saturated sediments by impacting missiles, and (2) fragmented material produced by two colliding spheres of basalt. M.W.R.

N66-21635*# Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES—SUMMARY Annual Progress Report, 1 Jul. 1964–1 Jul. 1965
Nov. 1965 34 p refs
(NASA Order R-66)
(NASA-CR-71419) CFSTI: HC $2.00/MF $0.50 CSCL 03B

This report summarizes the results of lunar and planetary studies, crater and solid state investigations, and cosmic chemistry and petrology research which were conducted to determine and map the stratigraphy and structure of the lunar crust, to determine the sequence of events that led to the present condition of the lunar surface, and to determine the processes by which these events took place. Part A contains results of detailed geologic mapping of 15 new lunar quadrangles at a scale of 1:1,000,000. Results of new mapping of both volcanic and impact features and detailed studies of previously defined stratigraphic units are included. Systematic photometric, polarimetric, and infrared studies designed to asssist in the geologic mapping are discussed and a proposed method of improving selenodetic control by laser radar ranging is described. Part B contains the results of field and laboratory studies of crater phenomenology, including volcanic, explosive, and impact events. Part C includes reports dealing with the techniques of study, the analysis, and the interpretation of data on materials of known or suspected extraterrestrial origin. R.N.A.

N66-21679*# Harvard Coll. Observatory, Cambridge, Mass.
MODELS OF THE LUNAR SURFACE INCLUDING TEMPERATURE-DEPENDENT THERMAL PROPERTIES Scientific Report No. 8
Jeffrey L. Linsky 15 Jan. 1966 90 p refs
(Grant NsG-64-60)
(NASA-CR-71554) CFSTI: HC $3.00/MF $0.75 CSCL 03B

The thermal conditions in the lunar surface are considered on a gross scale in terms of models with temperature-dependent thermal properties, including radiative energy transport. Agreement is obtained with infrared measurements of cold terminator temperatures and radio lunation data at millimeter wavelengths for a range of postulated parameters of the surface material. The observed increase of mean radio brightness temperature with wavelength is interpreted as due to radiative energy transport and the resultant nonlinearity of the heat-conduction equation, rather than to a large radioactive heat flux. The postulated existence of radiative energy transport is consistent with a porous or frothy medium, in agreement with photometric and laboratory simulation

experiments, as well as with recent radar depolarization measurements. A distance scale of 0.1–0.3 mm for the effective mean separation of radiating surfaces is suggested by this interpretation of the data. Author

N66-21782*# Boston Univ., Mass.
CATALOGUE OF LUNAR CRATERS CROSS SECTIONS. I: CRATERS WITH PEAKS Research Report No. 16
Gerald S. Hawkins, William H. Zack, and Stephen M. Saslow
Sep. 1965 115 p *Its* Astron. Contrib., Ser. II, no. 41
(Grant NsG-246-62)
(NASA-CR-71543) CFSTI: HC $4.00/MF $0.75 CSCL 03B

Graphical and digital representations of lunar craters possessing centrally located peaks are presented. Two to eight profiles were drawn for each peaked crater and digital tables compiled by interpolating data from the profiles. N.E.N.

N66-22175*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE POSSIBILITY OF RADIO NOISE FROM THE LUNAR RED SPOTS
John A. O'Keefe [1965] 4 p refs Submitted for Publication
(NASA-TM-X-56088) CFSTI: HC $1.00/MF $0.50 CSCL 03A

The explanation of small red spots near Aristarchus and other lunar craters is discussed. Based on observations of molecular hydrogen lines in the spectrogram of the spot near Aristarchus, it is suggested that the red spots are produced by static electric discharges through the H_2 which emerges above small lunar ash flows. It is concluded that the static electrical discharges, or lunar lightning, could produce radio noise of an order of magnitude within the capability of radio telescopes. N.E.N.

N66-22235*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
TEKTITES AS A GUIDE TO THE STRUCTURE OF THE MOON
John A. O'Keefe and Paul D. Lowman, Jr. [1965] 20 p refs Submitted for Publication
(NASA-TM-X-56663) CFSTI: HC $1.00/MF $0.50 CSCL 03B

This paper attempts to prove the lunar origin of tektites which then can be used to analyze the lunar surface. Evidence and arguments are presented which support the view that tektites are the products of meteorite impact on the moon which have been captured by the earth. Several large tektite strewfields are described and theories for both earth and lunar impact origins are discussed. Comparisons are made between Ranger photographs and similar earth features to lend support to the lunar origin of tektites. The speculations offered, though plausible, are concluded to be no more than speculations as there is no way of confirming that the lunar surface is genuinely like tektites in its chemical composition, short of obtaining an actual lunar sample. R.N.A.

N66-22256*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE DIRECTIONAL RADIATIVE CHARACTERISTICS OF CONICAL CAVITIES AND THEIR RELATION TO LUNAR PHENOMENA
Leslie G. Polgar and John R. Howell Washington, NASA, 1965 15 p refs Presented at the AIAA/ION Astrodyn. Specialists Conf., Monterey, Calif., 16–17 Sep., 1965
(NASA-TM-X-52090) CFSTI: HC $1.00/MF $0.50 CSCL 20M

An analytical study of the directional absorptivity characteristics of conical cavities is presented in an attempt to model the reflectivity characteristics of the lunar surface. A beam of parallel radiation is taken as striking a right circular conical cavity at a given angle of incidence to the cone axis. The cone is assumed to have a diffusely reflecting surface and has a given cone angle. A Monte Carlo analysis is used to determine the directional reflectivity of the cone. Parameters varied are the cone angle, surface absorptivity, and angle of incidence of the solar radiation. A comparison is then made to the lunar characteristics. The directional reflectivity of a right circular cone with a 30° cone angle and a 0.5 surface absorptivity compared well with experimental photometric results for the lunar surface. This infers that the lunar surface could have steep walled cavities larger than visual wavelengths. Results for conical cavities with cone angles near those for observed lunar craters do not correlate with observed lunar photometric results, implying that they contribute little to the lunar reflectivity characteristics. R.N.A.

N66-22367*# Aero Vac Corp., Troy, N. Y.
INVESTIGATION OF VACUUM PUMPING ON BEDS OF SOIL MATERIALS Final Report
16 Feb. 1966 20 p
(Contract NAS1-5434)
(NASA-CR-66079) CFSTI: HC $1.00/MF $0.50 CSCL 14B

The purpose of the investigation was to determine the pumping load and time required if beds of soil materials are placed in a vacuum chamber. The vacuum chamber used had a volume of approximately four cubic feet and could be pumped down to 10^{-8} torr when empty. Various sizes of soil beds were placed in the chamber. The beds were composed of either 500 micron or 5 micron particles of aluminum oxide. No particular difficulty was encountered in pumping beds of dry material (less than 0.1 percent moisture). A bed of fine material with 0.5 percent moisture erupted violently, due to sudden release of the moisture from the bed. Author

N66-22781# Manchester Univ. (England). Dept. of Astronomy.
THREE COLOUR PHOTOELECTRIC PHOTOMETRY OF THE MOON Interim Scientific Report No. 1
G. L. Roberts Jul. 1965 82 p refs
(Contract AF 61(052)-882)
(AFCRL-66-14; AD-628557) CFSTI: HC $8.60/MF $0.75

This report describes experiments attempting to measure the time variation of the luminescence of the lunar surface material, assuming a luminescence band for the surface material similar to that stimulated in certain meteorite samples in the laboratory. The two instruments used are described briefly and a discussion of the results obtained, both in the laboratory and at the telescope, is given. Author (TAB)

N66-22886*# Geological Survey, Flagstaff, Ariz.
INVESTIGATION OF *IN SITU* PHYSICAL PROPERTIES OF SURFACE AND SUBSURFACE SITE MATERIALS BY ENGINEERING GEOPHYSICAL TECHNIQUES Project Quarterly Report, 1 Oct.–31 Dec. 1965
Joel S. Watkins, ed. Feb. 1966 119 p refs
(NASA ORDER T-25091-G)
(NASA-CR-65320) CFSTI: HC $4.00/MF $0.75 CSCL 08K

CONTENTS:

N66-22888 Geological Survey, Flagstaff, Ariz.
FIELD VERIFICATION OF *IN SITU* PHYSICAL PROPERTIES
Carl H. Roach and Gordon R. Johnson *In its* Invest. of *In Situ* Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. Feb. 1966 p 9–46 (See N66-22886 12-13) CFSTI: HC $4.00/MF $0.75

Bulk densities, grain densities, porosities, effective porosities, and permeabilities have been determined for core samples obtained from basaltic lava near Amboy, California, rhyolitic tuff north of Bishop, California, granite from Sonora Pass in the Sierra Nevada of eastern California, pumice from Southern Coulee of Mono Craters, California, and andesitic basalt from S P flow north of Flagstaff, Arizona. These parameters have been related to local variations in geologic structure and constitute an initial effort in the compilation of physical properties of a suite of probable lunar analog rock types and structures. A brief description of techniques is presented. Author

N66-23051 Arizona Univ., Tucson. Lunar and Planetary Lab.
RANGER EXPLORATION OF THE MOON
Ewen A. Whitaker *In* Southwest Res. Inst. Bioastronautics and the Exploration of Space Dec. 1965 p 39–58 (See N66-23048 12-04) CFSTI: HC $9.40/MF $2.50

A discussion is presented of various Ranger VII photographs of the moon relative to determining a site for the landing phase of the Apollo project. Consideration is given to earth based observations, the impact site for Ranger VII, and features of the photographs. Emphasis is placed on tentative conclusions which are explained with reference to the various photographs. C.T.C.

N66-23175 Ewen Knight Corp., East Natick, Mass.
REFRACTION MEASUREMENTS BY LUNAR TRACKING
H. I. Ewen and P. M. Kalaghan *In* Mitre Corp. Proc. of the 3d Tropospheric Refraction Effects Meeting, Vol. II Jan. 1966 p 405–429 refs (See N66-23166 12-07) CFSTI: HC $6.00/MF $1.50

A systems analysis on the overall utility of the moon in measuring pointing errors of current radar systems was performed and established the feasibility of enhancing radio brightness of the lunar surface by means of active illumination from an earth-based C-band transmitter. This method makes highly accurate tracking of a subterrestrial point for an earth-based receiver system possible; it can also be used to calibrate the quality of tracking data by comparing the predicted position of the moon to the known position given by an ephemeris. G.G.

N66-23475*# National Aeronautics and Space Administration, Washington, D. C.
SIGNIFICANT ACHIEVEMENTS IN PLANETOLOGY, 1958–1964
[1964] 81 p refs
(NASA-SP-99) GPO: HC $0.45; CFSTI: MF $0.75 CSCL 03B

Studies of the earth relating to extraterrestrial bodies are discussed, and the results obtained from the Mariner II and Ranger VII spacecraft probes are described. Data are grouped according to the type of observation: earth-based measurements of electromagnetic radiation from the moon and planets; simulations and terrestrial-counterpart studies; investigations of chemical-mineralogical composition and genesis; and spacecraft observations. Instrumentation developed for space research is also discussed, in relation to the advantages obtained by making measurements close to lunar or planetary objects. The problems facing the planetologist are assessed, and applications of planetology research results are outlined. M.G.J.

N66-23653*# Texaco, Inc., Bellaire, Tex. Research and Technical Dept.
PHYSICAL PARAMETERS INSTRUMENTATION FOR SURVEYOR INTERFACE AND DESCRIPTIVE INFORMATION
21 Apr. 1961 65 p Prepared for JPL
(Contract NASw-6)
(NASA-CR-74296) CFSTI: HC $3.00/MF $0.75 CSCL 14B

Presented is descriptive and interface information for the Surveyor instrumentation to measure physical parameters on and beneath the lunar surface. Each instrument is treated as a separate unit that evaluates either temperature, thermal diffusivity, magnetic susceptibility, resistivity, density, hardness, or acoustic velocity. Instrumentation subsystems for operating beneath the lunar surface constitute acoustic detectors in downhole sonde. G.G.

N66-23761*# Texaco Experiment, Inc., Richmond, Va.
PENETROMETER Final Acceptance Test Report
26 Feb. 1962 95 p Prepared for JPL
(Contracts NASw-6; JPL-950155)
(NASA-CR-74242; JPL-TM-1330; EXP-387) CFSTI: HC $3.00/MF $0.75 CSCL 14B

This report presents the results of acceptance tests on penetrometers designed to determine the penetration resistance of the lunar surface material. The test equipment and procedures are described. The results, presented in graphical and tabular form, are given for man-made and natural materials, variable drop height tests, vacuum chamber tests, variable temperature tests, and comparison tests of different accelerometers. R.N.A.

N66-23763*# Texaco, Inc., Bellaire, Tex.
LUNAR DRILL FEASIBILITY STUDY Final Report
13 Jan. 1961 43 p refs Prepared for JPL
(Contracts NASw-6; JPL-N-33552)
(NASA-CR-74239) CFSTI: HC $2.00/MF $0.50 CSCL 08I

A study was conducted to determine the feasibility of a device for producing a hole in the lunar surface. The study includes both a literature survey and an experiment program. The experimental program investigated both rotary and percussive drilling with low thrust and no flushing fluid. Rotary drilling does not appear feasible due to the lack of sufficient thrust for effective cutting. Percussive drilling, on the other hand, appears to be quite acceptable for producing the required hole and is capable of reasonable drilling rates when the cuttings are removed from the hole mechanically.
Author

N66-23947# Illinois Univ., Urbana. Electrical Engineering Research Lab.
IONOSPHERIC RESEARCH Ninth Quarterly Progress Report, 1 Oct.–31 Dec. 1965
Harold D. Webb [1966] 18 p
(Contract DA-36-039-AMC-03703(E))
(Rept.-9; AD-629449) CFSTI: HC $1.60/MF $0.50

Moon-reflected signals at 150.6 mcps were received on 34 days for a total of approximately 252 hours. Moon-reflected signals at 413.25 mcps were received on all of these days. The Faraday rotation angles have been read from the strip charts obtained at the two frequencies. The data at 413.25 mcps are used to resolve the NX180° ambiguity in the 150.6 mcps data. Calculations of electron content have been completed for the observations through November 3, 1965. The California Computer Products plotter has been used to plot the Faraday rotation and electron content values for all of the data from July 1961 through 1964 and for some of the 1965 data. An atlas of Faraday rotation and electron content data for July 1961 through 1964 is being prepared under contract AMC 01710(E). The data has been machine plotted and the graph sheets are being prepared. A phase lock receiver has been designed and built for use in keeping the 150.6 mcps receiver on signal. Two bioconical, spiral, circularly polarized antennas have been designed, built and tested. These antennas were designed for use in measuring the depolarization at the surface of the moon. Author

N66-24202# Extraterrestrial Research Center, Ann Arbor, Mich.
APOLLO APPLICATIONS PROGRAM Bibliography
Apr. 1966 618 p Prepared for Gen. Dyn./Convair

An annotated bibliography is presented for experiments related to the Apollo Applications Program. The major portion of the reference material is devoted to earth orbit experiments, and includes reviews of studies dealing with the atmosphere and astronomy, biomedicine and astronaut behavior, communications and navigation, earth sciences and resources, subsystem development, and related physical sciences. Lunar orbit and surface experiments are reviewed; and cover such subjects as electromagnetic sensing, gravity and micrometeorite measurements, and the various scientific disciplines. Also included are a number of general references, relating to flights, problems in space, and unmanned probes.
M.W.R.

N66-24366# Joint Publications Research Service, Washington, D. C.
FIGURE AND MOTION OF THE MOON
A. A. Yakovkin, ed. 28 Apr. 1966 157 p refs Transl. into ENGLISH of the book "Figura i Dvizheniye Luna" Kiev, Naukova Publ. House, 1965 p 5–137
(JPRS-35227; TT-66-31664) CFSTI: $4.00

CONTENTS:

N66-24367# Joint Publications Research Service, Washington, D. C.
STATUS OF THE PROBLEM OF LUNAR PHYSICAL LIBRATION AND FUTURE DEVELOPMENT IN THIS FIELD
A. A. Yakovkin *In its* Figure and Motion of the Moon 28 Apr. 1966 p 1–4 (See N66-24366 13-30) CFSTI: $4.00

A theory to determine the lunar orbit without error is presented. The coordinates of any point on the visible lunar surface are computed from their relationships to a conversion point obtained by occultation, meridian observation, and limb point photography. Thus, the relief of the limb zone is related to the center of the lunar mass by the physical libration parameters of crater positions, and by recomputation of the conversion point system to a system of barycentric coordinates.
G.G.

N66-24368# Joint Publications Research Service, Washington, D. C.
DETERMINATION OF THE CONSTANTS OF LUNAR PHYSICAL LIBRATION BY THE POSITION ANGLES METHOD FROM VISUAL OBSERVATIONS
A. A. Gorynya *In its* Figure and Motion of the Moon 28 Apr. 1966 p 5–22 refs (See N66-24366 13-30) CFSTI: $4.00
A total of 50 refractory observations of position angles of pairs of moon craters were used to determine the parameters of the lunar physical libration. Computed coordinates values for the craters in oblique projection were expressed in fractions of the earth's equator and then used to obtain the theoretical position angles of the crater Moesting A in relation to a limb crater in an eleiptic coordinate system. Measured angles were corrected for the setting of the instrument and for differential refraction. A list of observed craters with their computed observed and theoretical position angles was enclosed. G.G.

N66-24369# Joint Publications Research Service, Washington, D. C.
ON DETERMINING THE CONSTANTS OF LUNAR PHYSICAL LIBRATION
A.A. Gorynya *In its* Figure and Motion of the Moon 28 Apr. 1966 p 23–27 refs (See N66-24366 13-30) CFSTI: $4.00
Analyses of lunar photographs, based on the various position angles of crater pairs, were used to determine the inclination of the lunar equator to the ecliptic and the function of lunar moments of inertia. Computations with the initial value $f=0.60$ resulted in considerable deviations from the true value of f. The true value of f in any case was greater than the critical value $f=0.662$. G.G.

N66-24371# Joint Publications Research Service, Washington, D. C.
SELENOCENTRIC COORDINATES OF 160 BASE POINTS ON THE LUNAR SURFACE
I. V. Gavrilov, A. S. Duma, V. S. Kislyuk, and A. N. Kur'yanova *In its* Figure and Motion of the Moon 28 Apr. 1966 p 36–55 refs (See N66-24366 13-30) CFSTI: $4.00
Sixteen lunar photographs, obtained close to midnight, were measured in order to construct a network of base points with known horizontal and vertical coordinates for a final list of reference craters. Results of these measurements, together with data from the Schrutka–Rechtenstamm catalog, served as basis for a composite space coordinates catalog of 160 base points presented in this study. G.G.

N66-24372# Joint Publications Research Service, Washington, D. C.
A METHOD FOR LUNAR POLYGONOMETRY
I. V. Gavrilov *In its* Figure and Motion of the Moon 28 Apr. 1966 p 56–74 refs (See N66-24366 13-30) CFSTI: $4.00
Point positions on the lunar surface were determined by a coordinate system related to the lunar center of mass. Considered was a system of rectangular selenocentric coordinates whose plane coincided with the plane of the lunar equator, and whose coordinate axes were directed along the axis of rotation and the prime axis, respectively. The position of the coordinate planes of these systems in the body of the moon were then fixed by some number points with known space coordinates obtained from photographs of crater pairs. Compilation of the composite catalog was done by coordinate averaging without their reduction. G.G.

N66-24373# Joint Publications Research Service, Washington, D. C.
DETERMINING THE SELENOGRAPHIC COORDINATES OF POINTS ON THE LUNAR SURFACE AND DISTANCES BETWEEN THEM IN THE PHOTOMETRIC METHOD FOR INVESTIGATING SLOPES
L. R. Lisina and V. V. Shevchenko *In its* Figure and Motion of the Moon 28 Apr. 1966 p 75–86 refs (See N66-24366 13-30) CFSTI: $4.00
A solution to the orientation problem of a lunar negative, and the determination of selenographic coordinates of points and distances for establishing the slopes of lunar surfaces, was found by accurate measurements of rectangular point coordinates on the negative. The mathematical dependence between the true surface of the moon and its plane image as it appeared on the photograph was established by considering an external oblique projection in which the distance D from the center of the projected sphere to the eye point was equal to the topocentric distance from the earth to the moon. With conversion from a sphere to a plane in an orthographic projection, all the circles passing through the center of the projection were represented by straight lines and the angles between them were not distorted. Thus, the distance was determined through the rectangular coordinates of the points with good accuracy. G.G.

N66-24374# Joint Publications Research Service, Washington, D. C.
COMMUNICATION ON COMPUTATION OF THE EPHEMERIS OF MOESTING A
A. A. Yakovkin *In its* Figure and Motion of the Moon 28 Apr. 1966 p 87–92 (See N66-24366 13-30) CFSTI: $4.00
Optical and physical midnight libration data were used to compute the ephemerides of lunar craters in the center region of the moon. Triangulation techniques were used to reduce the entire computation of two formulas expressing the angle at which the arc between the earth and the crater Moesting was visible from the center of the moon, and the position angle of the lunar axis. The topocentric libration was then obtained from the known geocentric libration. G.G.

N66-24375# Joint Publications Research Service, Washington, D. C.
DETERMINING EQUINOX CORRECTIONS FROM LUNAR OBSERVATIONS BY THE NEWCOMB METHOD
D. P. Duma *In its* Figure and Motion of the Moon 28 Apr. 1966 p 93–99 refs (See N66-24366 13-30) CFSTI: $4.00
Equinox corrections from observations of the Sun, Mercury, Venus, and Moon were compared with those obtained from lunar observations by the Newcomb method. It was found that in general corrections based on lunar observations gave a better convergence of individual results than observations of other objects. Discrepancies in five equinox corrections obtained from lunar crater meridian observations were improved by using a uniform distribution of right ascension observations in the Newcomb method of calculations. G.G.

N66-24377# Joint Publications Research Service, Washington, D. C.
DETERMINATION OF THE EQUINOX CORRECTION FROM OBSERVATIONS OF MOESTING A
D. P. Duma *In its* Figure and Motion of the Moon 28 Apr. 1966 p 108–113 refs (See N66-24366 13-30) CFSTI: $4.00

A series of meridian observations of the lunar crater Moesting A during 1923 to 1954 were analyzed to determine the elements of orientation for a fundamental catalogue. The series covered almost two full revolutions of the lunar nodes; all observations were grouped in hours for right ascension in order to decrease the number of required condition equations. Corrections of Newcomb's equinox, obtained from observations of Moesting A in the variants $-0^s \pm 0^s006$, $-0^s098 \pm 0^s$, and $-0^s097 \pm 0^s006$ were found too large in absolute value and agreed poorly with existing value as computed from observations of the sun, or large and small planets. G.G.

N66-24380# Joint Publications Research Service, Washington, D. C.

REPORT ON THE SESSIONS OF THE SECOND ALL-UNION CONFERENCE OF THE SUBCOMMISSION OF THE ASTRONOMICAL COUNCIL ACADEMY OF SCIENCES USSR ON THE STUDY OF THE FIGURE AND MOTION OF THE MOON

In its Figure and Motion of the Moon 28 Apr. 1966 p 122–133 (See N66-24366 13-30) CFSTI: $4.00

The following brief reports were presented: (1) *Determination of the Parameters of Lunar Rotation from a Tie-in of a Crater to Stars*—corrections for lunar declinations as caused by the libration effect in radius; (2) *Problems of Selenodesy and Absolute Lunar Hypsometry*—review of principle studies; (3) *Mapping of the Visible Parts of the Moon*—creation of multisheet detailed map; (4) *Optical Probing of the Moon*—recording of reflected signals; (5) *Processing of Stereotelescopic Lunar Photographs*—reliable construction of lunar relief; (6) *Accuracy of the Profile of the Lunar Limb Zone Using Data from Photoelectric Observations*—comparison with corresponding established profiles; and (7) *Results of Several Position Observations of the Moon and Their Use in Astronomy, Geodesy, and Meteorology.* G.G.

N66-24383*# Wheeler Labs., Inc., Great Neck, N. Y.

STUDY OF SMALL OMNIDIRECTIONAL 250-Mc ANTENNA FOR PENETROMETER Final Report

Robert E. Puttre et al 29 Jul. 1965 107 p refs *Its* Rept.-1291

(Contract NAS1-4470)

(NASA-CR-66091) CFSTI: HC $4.00/MF $0.75 CSCL 09F

A small rugged omnidirectional antenna is a component of a device called a penetrometer. This device can be employed to investigate certain of the physical characteristics, including hardness, penetrability and load-support capability, of unknown surfaces such as that of our moon. The proposed antenna comprises a pair of orthogonal loops fed in quadrature for spherical-pattern radiation coverage. The loops are resonated by the series capacitors and are mounted outside of a shielded spherical core containing a telemetry transmitter, accelerometer, battery, and a directional coupler for power division with quadrature phase. Calculations indicate that the encapsulated antenna will remain intact during and after impact at 150 feet per second on a hard surface, but dynamic tests are needed for confirmation. For an antenna exactly tuned and operating at 250 Mc, with a loop radius of 1-21/32 inches, the power radiated into free space is -6 db from the power radiated from a lossless isotropic radiator. If the antenna is immersed in a dielectric medium of k$-$3, or impacted on a hard surface of k$-$7, the least power radiated toward a receiver directly overhead is computed to be -11 db and -10 db, respectively, from an isotrope. Increasing the operating frequency or the size of the antenna increases the efficiency and reduces the sensitivity to environment. Author

N66-24596*# Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.

EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Seventh Quarterly Progress Report, 1 Jan.–31 Mar. 1966

J. A. Ryan 26 Jun. 1964 24 p

(Contract NAS7-307)

(NASA-CR-74625) CFSTI: HC $1.00/MF $0.50 CSCL 22A

In studying the ultra high vacuum frictional-adhesional behavior of silicates, data reproducibility for various silicate pairs was determined. Runs were made for hypersthene contacting orthoclase, albite contacting orthoclase, and hornbende contacting bytownite. Silicate-metal runs were also made for aluminum and magnesium alloys, and nickel contacting orthoclase. It was found that general adhesion behavior was reproducible, although some differences in adhesion magnitude were recorded. This difference appears to be due to surface roughness effects. The vacuum system was modified to permit vacuum cleavage, and two runs involving vacuum cleavage were made. The adhesion forces were found to be large, and a strong long range attractive force was present. It was concluded, tentatively, that the adhesion was caused by normal silicate bonding forces, and long range force was due to surface charging produced by a statistical charge separation during cleavage. A.O.

N66-24605*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Geo-Astrophysics Section.

CORRELATION OF MECHANICAL AND THERMAL PROPERTIES OF EXTRATERRESTRIAL MATERIALS Second Quarterly Progress Report

J. D. Halajian and J. Reichman Feb. 1966 50 p refs

(Contract NAS8-20084)

(NASA-CR-71750; RM-309) CSCL 03B

In correlating the thermal and mechanical properties of lunar surface materials, mathematical models for surface temperature changes were developed. Two-layer models were analyzed in terms of the thermal intertia constant, and thickness of the layers. It was found that midnight temperatures define these parameters and that, for midnight temperatures above 110°K, the models converge to a homogeneous model for sufficiently large upper layer thicknesses. Using the particulate model, analytical expressions for the solid and radiative components of powder thermal conductivity were developed as a function of porosity, particle size, emissivity, and temperature. The mechanical properties of powders are also discussed with emphasis on the underdense variety. In conclusion, it is stressed that the lunar thermal parameter is far more sensitive to changes of nighttime temperatures than noon temperatures, and that midnight temperature data suggest the lunar surface is not as homogeneous on a km-scale as it appears to be at larger scales. A.O.

N66-24907*# National Aeronautics and Space Administration, Washington, D. C.

A PHOTOMETRIC INVESTIGATION OF THE PRESENCE OF OUTER LAYERS OF VOLCANIC ORIGIN ON THE MOON [FOTOMETRICHESKOYE ISSLEDOVANIYE VOPROSA O NALICHII NA LUNE POKROVOV VULKANICHESKOGO PROISKHOZHDENIYA]

V. V. Sharonov May 1966 22 p refs Transl. into ENGLISH from Astron. Zh. (Moscow), v. 42, no. 1, 1965 p 136–144

(NASA-TT-F-9322) CFSTI: HC $1.00/MF $0.50 CSCL 03B

As the mean albedo of the moon is smaller than that of sedimentary and ordinary magma rocks, a photometric study was made of some of the outer layers in the neighborhood of active volcanoes, many of which have a dark color. It was

found that the volcanic sands, slags and lapilli, according to their small albedo and to their color characteristics are sufficiently similar to details of the lunar surface. A study of the reflection diagram shows that volcanic ash has a symmetrical diagram and cannot therefore be abundant on the moon. Areas of lapilli and especially flows of block lava, covered by a crust of reticulated slags, have the same type of diagram as the lunar surface. However the elongation is smaller than that for the moon and this indicates a jagged topography. Thus, according to photometric data, there is a similarity between the lunar surface and volcanic layers. The exceptional photometric uniformity of the lunar surface favors the hypothesis that cosmical factors are responsible for lunar surface layer formation. Author

N66-24927*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
CHRONOLOGICAL LISTING OF LUNAR EVENTS
B. M. Middlehurst (Arizona Univ.) and J. M. Burley Apr. 1966 46 p refs
(NASA-TM-X-55470; X-641-66-178) CFSTI: HC $2.00/MF $0.50 CSCL 03A

A complete catalog of observed and recorded lunar events over the past four centuries, i.e., 5 March 1587 to 15 November 1965, is presented, with references. A lunar event is defined as a temporary change in the appearance of a lunar feature, involving a limited area (in most cases, in terms of a few square kilometers) of the lunar surface. D.T.

N66-24932*# National Aeronautics and Space Administration, Washington, D. C.
LUNAR SURFACE STUDIES A Continuing Bibliography, With Indexes
Apr. 1966 70 p
(NASA-SP-7003(02)) CFSTI: HC $1.00/MF $0.75 CSCL 03B

An annotated bibliography is presented with abstracts, and author and subject indexes. Specific topics include the theory of lunar origin, the lunar atmosphere, and the physical characteristics of the lunar surface, e.g., topography, geology, cartography, and stratigraphy. Techniques of lunar observation, measurement, and analysis are covered, along with instrumentation and equipment used in lunar investigations. D.T.

N66-25046*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RANGER VIII AND IX. PART II: EXPERIMENTERS' ANALYSES AND INTERPRETATIONS
Raymond L. Heacock, Gerard P. Kuiper, Eugene M. Shoemaker, Harold C. Urey, and Ewen A. Whitaker 15 Mar. 1966 182 p refs
(Contract NAS7-100)
(NASA-CR-74894; JPL-TR-32-800) CFSTI: HC $5.00/MF $1.25 CSCL 22A

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11. PRELIMINARY GEOLOGIC MAP OF A SMALL AREA IN MARE TRANQUILLITATIS N. J. Trask (Geological Survey) p 319–326 refs (See N66-25057 13-30)
12. GEOLOGY OF MARE TRANQUILLITATIS AS SHOWN IN THE HIGH-RESOLUTION RANGER VIII PHOTOGRAPHS E. M. Shoemaker (Geological Survey) p 327–332 refs (See N66-25058 13-30)
13. EARLY APOLLO EXPLORATIONS E. M. Shoemaker (Geological Survey) p 332–335 refs (See N66-25059 13-30)
14. OBSERVATIONS ON THE RANGER VIII AND IX PICTURES H. C. Urey (Calif. Univ.) p 339–362 refs (See N66-25060 13-30)
15. PRODUCTION OF THE RANGER BLOCK III PHOTOGRAPHIC RECORDS E. A. Whitaker (Arizona Univ.) p 363–382 (See N66-25061 13-14)

N66-25047*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
RANGER BLOCK III
Raymond L. Heacock *In its* Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 7–34 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The contribution of Rangers VII, VIII, and IX to selenography are discussed. Pre-Ranger lunar data obtained by direct and indirect observations and through supporting laboratory studies are reviewed. The three successful Ranger missions are considered to have adequately categorized the small scale topography of a red mare (Mare Cognitum), a blue mare (Mare Tranquillitatis), and highland crater-floor terrain (crater Alphonsus). The use of the digital computer in processing the photographs and also the photographs themselves are discussed. It was concluded that the topography holds no serious hazards for unmanned or manned landings. It was further concluded that the observed topography is the result of primary meteorite and secondary ejecta bombardments. It is apparent that the highland terrain has been extensively modified, and that the highland crater floors and basins are filled with debris possibly to depths of thousands of meters. Evidence for relatively recent or presently existing internal activity is mentioned. N.E.N.

N66-25048*# Arizona Univ., Tucson. Lunar and Planetary Lab.
INTERPRETATION OF THE RANGER RECORDS
Gerard P. Kuiper, Robert G. Strom, and Rudolf S. Le Poole *In* JPL Ranger VIII and IX Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 35–248 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The lunar collapse depression, structures of mares and craters, and lineaments are discussed. A study of terrestrial collapse depressions was made to help understand the unexpected lunar collapse depressions. The circularity and the near-vertical orientation of the fracture plane in collapse depression in terrestrial lava fields is mentioned. The structure of Mare Tranquillitatis is discussed with respect to primary and secondary impact craters and circular collapse depressions; square, linear-beaded, and irregular collapse depressions; mare ridges; lineaments; and fine structure. The tentative conclusions on the structure of the crater Alphonsus are reported, concerning the central peak, the dark halo craters and rilles, the crater walls, and the nature of the crater floor. The size-frequency distribution of different classes of lunar craters and their areal densities were investigated. The domical struc-
N.E.N.

N66-25049*# Geological Survey, Flagstaff, Ariz.
SIZE AND SPATIAL DISTRIBUTION OF CRATERS ESTIMATED FROM THE RANGER PHOTOGRAPHS
Newell J. Trask *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 252–263 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The size and spatial distribution of small craters on the moon are discussed, including ray areas on the maria, ray-free parts of the maria, and flat highland basin terrain on the crater floor. Crater distributions from Ranger VII, VIII, and IX photographs were observed to have a tendency for the total crater densities to converge at small crater diameters. A possible steady state size-frequency distribution function for craters of all sizes on the level parts of the moon was estimated. The occurrence of secondary impact craters in significant numbers was interpreted as the principle cause for the rapid increase in the density of crater with diameters between 2 and 6 km. The local differences in crater density in the highlands east of Alphonsus are discussed. Graphs for the cumulative size-frequency distribution of craters are presented.
N.E.N.

N66-25050*# Geological Survey, Flagstaff, Ariz.
COHESION OF MATERIAL ON THE LUNAR SURFACE
Henry J. Moore *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 263–270 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

Two lunar crater morphologies are compared, based on Ranger IX photographs. The important features associated with the two craters are: little evidence of blocks on the rims and around the craters; low, lumpy structures on the walls, the rims, and around the craters; asymmetrical rims which are higher and wider on one side than the other; slopes that are less than 45° and probably near 35° or less; and a scalloped rim on one crater. The craters are discussed, and compared with man-made craters on the earth. It was suggested that the lunar surface materials are weakly cohesive to noncohesive.
N.E.N.

N66-25051*# Geological Survey, Flagstaff, Ariz.
THE STRUCTURE AND TEXTURE OF THE FLOOR OF ALPHONSUS
Michael H. Carr *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 270–275 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The textural units, the lineaments and structurally controlled craters on the floor of Alphonsus are discussed. The size-frequency distribution of craters is shown. The distribution of craters larger than 0.3 km was found to differ over the floor, but the density of smaller craters is essentially uniform. Three sets of lineaments were observed to belong to the lunar grid system, and a fourth to be radial to the center of Mare Imbrium. The observable lineaments are reported to be undeflected as they cross topographic features. It is suggested that the alignment of craters along lineaments is strong evidence that many craters were formed by mechanisms originating within the moon.
N.E.N.

N66-25052*# Geological Survey, Flagstaff, Ariz.
LUNAR PATTERNED GROUND
Eugene M. Shoemaker *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 275–284 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The pattern of low ridges and troughs on the lunar surface observed in Ranger photographs is discussed. A tendency was found for the predominant orientations of the linear elements of the lunar patterned ground to be parallel with the larger lineaments. It is suggested that this parallelism indicates that the patterned ground is controlled by underlying structures, which, in turn, are controlled by the regional structural pattern. The patterns are observable in the photographs of Mare Cognitum, Mare Tranquillitatis, and the crater Alphonsus floor. The probable relation of the lunar patterned ground to joints (fractures) and fissures in the underlying surface is discussed.
N.E.N.

N66-25053*# Geological Survey, Flagstaff, Ariz.
INVESTIGATION OF THE PHOTOGRAMMETRIC REDUCTION OF THE RANGER IMAGES
James D. Alderman, Warren T. Borgeson, and Sherman S. C. Wu *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 285–294 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The feasibility of systematic data reduction from Ranger stereoscopic coverage is discussed. The major problems, due to systems limitations, are cited as: the narrow angle lens systems; camera tilt; camera calibration; small base-to-height ratios; image motion and image blur; and video scan lines, image size, scale differences, low sun angle, and lunar photometric effects. These are considered in detail. The advantages of first-order plotters for data reduction are described, but it was felt that time and cost limitations prohibit their modification. Anaglyphic-type plotters were also considered, and the major problems associated with their use are listed. From preliminary test using an anaglyphic projection system, it was concluded that (1) the conditions are environmentally extrinsic to a photogrammetrist, and that (2) the quality of the Ranger images permits considerably more latitude in the model setup than is possible with conventional photographs. An image-blur analysis is included.
N.E.N.

N66-25054*# Geological Survey, Flagstaff, Ariz.
EXPERIMENTAL TOPOGRAPHIC MAP OF A SMALL AREA OF THE LUNAR SURFACE FROM THE RANGER VIII PHOTOGRAPHS
Henry J. Moore and Richard V. Lugn *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 295–302 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The preliminary topographic results from experiments undertaken to study the problems of design of an appropriate anaglyphic projection instrument are presented. The projector system is described, and the problems due to the Ranger VIII stereoscopic camera systems are discussed. It was concluded that the lunar photographs and experimental topographic maps do not conform to terrestrial mapping standards, but that important topographic data are obtainable with the use of photogrammetric techniques. N.E.N.

N66-25055*# Geological Survey, Flagstaff, Ariz.
GEOLOGY FROM A RELATIVELY DISTANT RANGER VIII PHOTOGRAPH
Daniel J. Milton and Don E. Wilhelms *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 302–313 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

Geologic mapping of Mare Tranquillitatis from distant Ranger VIII lunar photographs for classification of mappable units according to relative age, is described. The age and origin of structures and units for each age are discussed. Among the activities in geologic history inferred are: formation of a multiwalled ring structure and smaller craters in pre-Imbrian time; secondary impact cratering by ejections, intermittent volcanism forming plains and dome units, and faulting and filling in the Imbrian Period; formation of small craters, deformation of mare material by faulting, and formation of mare ridges in the Eratosthenian period; and formation of smaller craters, rays, and secondary impact craters, and sliding on steep slopes in the Copernican Period. N.E.N.

N66-25056*# Geological Survey, Flagstaff, Ariz.
INTERMEDIATE-SCALE GEOLOGIC MAP OF A PART OF THE FLOOR OF ALPHONSUS
John F. Mc Cauley *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 313–319 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The mapping from Ranger IX photographs of Alphonsus, showing the distribution of complex stratigraphic sequence of crater materials and smoother basin floor materials, is presented. Distinctions between the individual geologic units were made on the basis of morphology, slope angles, surface texture, crater density, and relative albedo. The systems and materials for the Imbrian, Eratosthenian, and Copernican Periods are discussed. A reconstructed sequence of events is given, from the original pre-Imbrian crater to the Eratosthenian period. N.E.N.

N66-25057*# Geological Survey, Flagstaff, Ariz.
PRELIMINARY GEOLOGIC MAP OF A SMALL AREA IN MARE TRANQUILLITATIS
Newell J. Trask *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 319–326 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

A preliminary geologic map for a small area in Mare Tranquillitatis covered by Ranger VIII was prepared. Discrimination of mappable units was based principally on albedo and topographic form. The Imbrian, Eratosthenian, and Copernican systems and materials are discussed. The stratigraphic succession in the map indicates that lunar surface materials darken with time. The mare ridges and scarps, and the lineaments are mentioned. The regularity of the lineaments is considered to indicate that they are of internal origin, reflecting a system of fractures or joints in the subsurface. N.E.N.

N66-25058*# Geological Survey, Flagstaff, Ariz.
GEOLOGY OF MARE TRANQUILLITATIS AS SHOWN IN THE HIGH-RESOLUTION RANGER VIII PHOTOGRAPHS
Eugene M. Shoemaker *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 327–332 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

A preliminary morphological classification of Mare Tranquillitatis from the last frames of Ranger VIII is discussed. The high resolution photographs permit a classification of mare craters and depressions and determination of stratigraphic relationships of materials. The morphological categories are: sharp rimmed craters; convex rim craters; funnel craters; dimple craters; low rim craters; and indefinite rim craters. The mare surface material was assigned to the Imbrian system. The materials of the Eratosthenian and Copernican ages from the various craters and depressions are described. Two types of structural features recognized are (1) a general northwest-tending alignment of indefinite rim craters and depressions, and (2) lineaments in and on the rim of the large low rim crater. N.E.N.

N66-25059*# Geological Survey, Flagstaff, Ariz.
EARLY APOLLO EXPLORATIONS
Eugene M. Shoemaker *In* JPL Ranger VIII and IX. Pt. II: Experimenters' Anal. and Interpretations 15 Mar. 1966 p 332–335 refs (See N66-25046 13-30) CFSTI: HC $5.00/MF $1.25

The scientific mission profiles for an early Apollo exploration on the moon are described. The major goals and fundamental constraints are given. The exploration time, astronaut mobility, and equipment are mentioned. The scientific activities for the three excursions are delineated. N.E.N.

N66-25371*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
APPARENT LUNAR ACTIVITY: HISTORICAL REVIEW
Jaylee Burley and Barbara M. Middlehurst (Arizona Univ.) Apr. 1966 13 p refs Presented at the NAS Symp. on Surface Features of the Moon, Seattle, 13 Oct. 1965 Submitted for Publication See N66-24927
(NASA-TM-X-55468) CFSTI: HC $1.00/MF $0.50 CSCL 03B

A historical review is presented on more than 200 lunar surface events observed and recorded over the past four centuries, i.e., 5 March 1587 to 15 November 1965. The material was analyzed with respect to (1) solar activity as measured by monthly sunspot numbers, and (2) tidal action by the earth. Based on the frequency distribution, which shows well defined peaks at perigee and apogee, of the sightings around the lunar orbit; it is concluded that the events are due to internal causes which are accelerated near perigee and apogee through tidal disruption. D.T.

N66-25575*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
INVESTIGATION OF LUNAR SURFACE CHEMICAL CONTAMINATION BY LEM DESCENT ENGINE AND ASSOCIATED EQUIPMENT
A. Buchler, A. Wechsler (Little (Arthur D.), Inc., Cambridge, Mass.), L. Aronowitz, C. Baulknight, F. Koch et al Jan. 1966 64 p refs
(Contract NAS9-4860)
(NASA-CR-65342; RE-237) CFSTI: HC $3.00/MF $0.75 CSCL 22A

An investigation of lunar surface and atmosphere contamination is summarized. Areas of investigation include: composition of inorganic, organic, and bacteriological contaminants; distribution of contamination on the lunar surface contamination of the lunar atmosphere; transient temperature distributions produced by rocket exhaust plume; possible chemical reactions between exhaust products and surface materials; and possible interactions between contaminant molecules and the surface. A set of proposed lunar models which are flexible enough to incorporate many hypothetical details of the lunar surface structure are described, along with methods and devices for minimizing and compensating for contamination. Finally, the Apollo scientific program and the consequences of cumulative contamination are discussed. D.T.

N66-25576*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
INVESTIGATION OF LUNAR SURFACE CHEMICAL CONTAMINATION BY LEM DESCENT ENGINE AND ASSOCIATED EQUIPMENT Final Report
L. Aronowitz, N. Milford, S. Penn, F. Pomilla, A. Wechsler (Little (Arthur D.), Inc., Cambridge, Mass.), et al Mar. 1966 215 p refs
(Contract NAS9-4860)
(NASA-CR-65341; RE-242) CFSTI: HC $6.00/MF $1.25 CSCL 22A

The composition was studied of inorganic and organic contaminants from the LEM descent engine exhaust and from gas vented from the ascent stage. Means for minimizing and compensating for contamination in samples were surveyed. Contamination due to bacteria and biological debris was examined; and it was concluded that unless specific measures are taken to prevent it, the probability of bacteriological sample contamination approaches 100%. A possible method for minimizing contamination is to collect them from regions that are partially or totally shielded from rocket exhaust gas. The Luna 9 photographs suggest that such regions may exist under rocks or inside cavities that are distant from the LEM touchdown point. Several devices are also suggested for minimizing contamination in samples. These include a sampling probe to be dropped from the LEM before or immediately after touchdown; and an instrument to be used by the astronaut that will decontaminate a portion of the lunar surface, and then take a sample at a sufficient depth below the surface to avoid further contamination. D.T.

N66-26083# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
THE CURRENT STATUS OF SELENODETIC CONTROL SYSTEMS
C. L. Goudas Feb. 1966 16 p refs *Its* Mathematical Note No. 453

A brief discussion of the problems encountered in determining absolute coordinates of lunar formations as well as an evaluation of the current status of control systems is given. It is concluded that a control system with errors not exceeding 0.2" geocentric in each cordinate is possible. Author

N66-26874*# Little (Arthur D.), Inc., Cambridge, Mass.
FAR INFRARED SPECTRA OF SILICATE MINERALS FOR USE IN REMOTE SENSING OF LUNAR AND PLANETARY SURFACES Final Report, Apr. 1965–Apr. 1966
James R. Aronson, Alfred G. Emslie, Ronald V. Allen, and Hugh G. Mc Linden 15 Apr. 1966 76 p refs
(Contract NAS8-20122)
(NASA-CR-75289; C-67323) CFSTI: HC $3.00/MF $0.75 CSCL 03B

This report is concerned with the results of an experimental and theoretical investigation of the far infrared spectra of silicate minerals for use in remote sensing of the composition of lunar or planetary surfaces. The subject matter consists of: (1) an examination of the spectral information that may be obtained from silicate minerals in the far infrared region; (2) a study of the effects of the state of surface aggregation, especially for fine particulate surfaces, on the information content of such spectra; (3) considerations of the ways in which the spectra of composite samples may be understood in terms of the spectra of their components, and (4) a brief description of the instrumental considerations that would be involved in utilizing these results on a space mission. Author

N66-26954# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
THE EXPLOITATION OF LUNAR NATURAL RESOURCES
S. Penn Dec. 1965 31 p refs Submitted for Publication
(RM-305J)

The possibility of there existing resources or materials on the moon which are valuable to man, and the further possibility of mining these resources are discussed. Included in this discussion are detailed hypothetical considerations of lunar surface texture and petrology, and lunar water resources. In addition, various electric power systems are examined for potential applicability in the exploration of the moon; and several methods are proposed for mining. D.T.

N66-26955# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
EXPERIMENTAL ASPECTS OF COMMINUTION IN VACUUM
G. Mohr Mar. 1966 32 p refs
(RM-313)

Past theoretical and experimental work in conventional crushing and grinding of particles is examined in order to determine its applicability to comminution experiments in ultrahigh vacuum. Furthermore, in the absence of precedents for the suggested investigation, the experimental aspects of this investigation are discussed. Notwithstanding the initial difficulties, the newly developed experimental techniques may open up new avenues to more comprehensive studies of surface formation and behavior at very low pressures. Or they may be used to complement existing experimental procedures that have been severely limited by the fact that the materials under study had to be produced under earth-ambient conditions prior to investigation. Author

N66-27054*# Grumman Aircraft Engineering Corp., Bethpage, N. Y.
PHOTOMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES Final Report
J. D. Halajian and F. A. Spagnolo Apr. 1966 166 p refs
(Contract NAS9-3182)
(NASA-CR-65365; RE-245) CFSTI: HC $5.00/MF $1.00 CSCL 03B

This study was conducted to determine engineering properties of the optical lunar surface by means of physical and theoretical models that obey known photometric properties of that surface. The photometric analyzer was overhauled and recalibrated. Major instrumental modifications include added filters for spectrophotometric measurements, and an enlarged beam splitter to record brightness changes near zero phase angles with high fidelity. Albedo and brightness were measured as a function of wavelength on six specimens ranging from fine powders to massive slags. Most specimens exhibit the opposition effect which is tentatively attributed to color and roughness effects. Their albedo is wavelength dependent. Experimental and analytical studies are made of the photometry of dust clouds leading to negative results which indicate that dust clouds fail to exhibit the lunar backscattering characteristics. Computer analyses are performed to correlate the photometric and geometric properties of various idealized patterns consisting of horizontal and/or vertical elements. Shadowing, albedo, and scattering law effects on the photometric function are analyzed and evaluated. Vertical elements, horizontal overhanging members, and secondary pits are shown to be necessary building blocks for a model that simulates lunar light backscatter. R.N.A.

N66-27192*# National Aeronautics and Space Administration, Washington, D. C.

RADIO EMISSIONS AND THE NATURE OF THE MOON [RADIOIZLUCHENIYE I PRIRODA LUNY]

V. D. Krotikov and V. S. Troitskiy Mar. 1964 73 p refs Transl. into ENGLISH from Usp. Fiz. Nauk (Moscow), v. 81, no. 4, Dec. 1963 p 584–639

(NASA-TT-F-8837) CFSTI: HC $3.00/MF $0.75 CSCL 03B

This article discusses the investigation of the physical conditions of the moon by means of its radio emission. Taken into consideration are the lunar-surface temperature, the structure of the lunar crust, the thermal properties of the lunar crust, density and dielectric constants of rocks in the lunar crust, and the thermal radiation and thermal state of the lunar interior. C.L.W.

N66-27244*# IIT Research Inst., Chicago, Ill. Technology Center.

STUDIES OF LUNAR SOIL MECHANICS Final Report, 15 Dec. 1965–1 Mar. 1966

E. Vey and John D. Nelson May 1966 163 p refs

(Contract NASr-65(02); ITTRI Proj. M272)

(NASA-CR-75323) CFSTI: HC $5.00/MF $1.00 CSCL 03B

An investigation was conducted on the effect of ultra-high vacuum on the properties of simulated lunar soils. The materials used consisted of fine grained powders of quartz, obsidian, enstatite and olivine. Fine grained enstatite sand was also used for a limited number of experiments. The results of direct shear tests and measurements of the resistance to dynamic penetration showed an increase in the soil strength under vacuum due to increases in both the stiffness and shear strength parameters. The magnitude of the increase, however, was dependent upon mineralogical composition because of variations in the amounts of initially adsorbed and/or absorbed gas. Static penetrometer experiments were also performed and the results correlated with the amount of gas desorbed from the soil prior to measuring the penetration resistance. The strength of the soil was observed to vary exponentially with the relative cleanliness and extrapolation of the results to atomically clean surfaces yielded values of penetration resistance substantially less than that of the same material sintered at high temperatures. Author

N66-27535*# Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.

A MISSION FOR SURVEYING AND MAPPING THE LUNAR SURFACE

S. N. Heaps Apr. 1966 87 p refs

(Contract NAS8-20166)

(NASA-CR-75417; R-192) CFSTI: HC $3.00/MF $0.75 CSCL 22A

A three-man lunar mission has been planned in which eleven remote sensing instruments are operated for eight days in a polar orbit. From the elevation of 81.5 km (44 n mi), the high resolution stereoscopic photographs and celestial navigation sightings provide accurate location data for the Earth-science observations. The mission is one of a series proposed under the Apollo Applications Program. Author

N66-27972# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.

ESTIMATES ON THE NEUTRON FLUX ON THE SURFACE OF THE MOON INDUCED BY SOLAR FLARES

Martin S. Spergel May 1966 24 p refs Presented at Ann. Meeting of Am. Geophys. Union, Washington, 19–22 Apr. 1966 Submitted for Publication

(RE-253J)

A theoretical calculation has been performed on the production, by solar flare protons, of neutrons within the lunar surface and the resulting neutron albedo flux at the lunar surface. The transport of the neutrons is approximated by a single, energy independent, exponential attenuation function. Effective neutron attenuation length is taken as the sum of the inelastic neutron scattering length and a fraction of the elastic neutron scattering length. The resulting neutron energy distribution will necessarily have the form of the production spectrum, which is that of the nuclear evaporation model. The incident solar flare proton flux is represented by an exponential rigidity spectrum. Ionization losses for the incident solar protons are calculated from estimates of the range of the protons within the lunar surface. The lunar medium is represented by an "average" chondritic material. The resulting neutron albedo is found for three different flares and for various values of the model's parameters. Author

N66-28217# Defence Research Board, Ottawa (Ontario). Directorate of Scientific Information Services.

RELATIVE DEPTHS OF LUNAR RING MOUNTAINS AND CRATERS IN THE MARE NUBIUM

A. V. Markov May 1966 8 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 167, no. 1, 1966 p 63–64

(T-457-R) CFSTI: HC $1.00/MF $0.50

Values for the logarithms of the diameters, D, and depths, d, of lunar craters and ring mountains (walled plains) in the zone of the Mare Nubium (around the impact point of the Ranger VII spaceship) for craters ranging from 8.0 m to 67,2000 m in diameter were compared for testing the correctness of a formula put forth by Baldwin for craters in which diameters range from 2.0 km to 200 km. The data indicate that Baldwin's formula does quite closely represent the relationship between diameter and depth for the lunar craters measured by the spacecraft photographs. Departures from the formula were observed though for the very large ring plains and for some other craters which the possibility exists that after their formation the bottom was inundated, from inside, by lava. L.S.

N66-28260# Aeronautical Chart and Information Center, St. Louis, Mo.
COORDINATES OF LUNAR FEATURES, GROUP I AND II SOLUTIONS
Donald L. Meyer and Byron W. Ruffin Mar. 1965 101 p refs
(ACIC-TP-15; AD-631404) CFSTI: HC $4.00/MF $0.75

A series of one to one million scale charts of the moon and charts of potential landing sites are produced at the scale of one to five hundred thousand. Inadequacies of existing lunar control have necessitated the establishment of a new control program for measuring and reducing positions using earth based telescope photography. It is the purpose of this report to present the measurement and reduction methods employed and the lunar coordinates derived from the first two photo groups of a planned four photo group solution.
Author (TAB)

N66-28464# Harry Diamond Labs., Washington, D. C.
OMNIDIRECTIONAL ACCELERATION SENSOR
A. J. Buschman, Jr. *In* NRL The Shock and Vibration Bull. Feb. 1966 p 55-60 refs (See N66-28456 16-32) CFSTI: HC $6.00/MF $1.25

An acceleration sensor that is independent of the direction of the acceleration vector has been developed for use in selection of a site for a manned lunar landing. This is accomplished by employing a triaxial accelerometer and a computer whose output is the square root of the sum of the squares of three orthogonal, acceleration-time signatures. The circuitry operates from a 20-V power supply drawing 10 mA and has a dynamic range of 1000. The triaxial accelerometer, computer, power supply, and telemetry can be packaged in a 3-in. diameter sphere. Author

N66-28482*# Litton Systems, Inc., Minneapolis, Minn. Applied Science Div.
INVESTIGATION OF SPUTTERING EFFECTS ON THE MOON'S SURFACE Quarterly Status Report No. 12, 25 Jan.–24 Apr. 1966
G. K. Wehner, C. E. Ken Knight, and D. L. Rosenberg 25 May 1966 59 p refs *Its* Rept.-2986
(Contract NASw-751)
(NASA-CR-75697) CFSTI: HC $3.00/MF $0.50 CSCL 03B

Attempts to build up thick crusts of powders which are ion bombarded during deposition and the study of changes in the permeability of solid rock samples due to ion bombardment were continued. A summary of the optical properties of the moon in comparison to those of ion bombarded powder samples is given in preparation for publishing the work of the last three years. Trends in sample color due to composition differences are presented. Though the color of lunar features should permit identification of composition differences after taking decoloration effects of the solar wind into account, positive identification is not now possible. A number of properties of the lunar photometric function plus the polarization of earthshine are shown to be incapable of proving whether the lunar surface is underdense or compacted. The photometric function reveals that the lunar surface has a rough macrostructure, the form of which may correspond in general to that seen in the photographs of Luna 9. The earlier conclusion that the polarization of moonlight is in good agreement with that of light scattered from powders whose particles are mostly less than 0.1 mm in size is not modified by the latest consideration of composition, density, and roughness of the lunar surface layer. Author

N66-28655*# Ewen Knight Corp., East Natick, Mass.
RADIO OBSERVATIONS OF THE MOON AND VENUS AT 8.6 mm WAVELENGTH Final Report, May 1, 1962–Nov. 1, 1965
[1965] 136 p refs
(Contract NASw-593)
(NASA-CR-75313) CFSTI: HC $4.00/MF $1.00 CSCL 03B

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3. OBSERVATIONS OF VENUS NEAR THE 1962 INFERIOR CONJUNCTION 7 p refs (See N66-28658 16-30)
4. OBSERVATIONS OF VENUS NEAR THE 1964 INFERIOR CONJUNCTION 10 p refs (See N66-28659 16-30)
5. ATMOSPHERIC EFFECTS ON CELESTIAL RADIO MEASUREMENTS AT 8.6 MILLIMETERS P. M. Kalaghan 33 p refs (See N66-28660 16-30)

N66-28656*# Ewen Knight Corp., East Natick, Mass.
THERMAL RADIATION FROM THE MOON AT 8.6 mm WAVELENGTH
In its Radio Observations of the Moon and Venus at 8.6 mm Wavelength [1965] 33 p refs (See N66-28655 16-30) CFSTI: HC $4.00/MF $1.00

Observations of the moon, with an angular resolution of 4×5-1/2 minutes of arc, were made at 8.6 mm wavelength during the one-year period from August, 1963 through August, 1964. By means of a raster scan technique, antenna temperatures as functions of local phase angle were obtained for four selected regions of the lunar surface. The data were corrected for radome attenuation, which was measured directly and daily corrections calculated from ground level meteorological data were made for the effects of atmospheric attenuation. The temperature versus phase angle curves were corrected for antenna smoothing before being examined from the standpoint of both one and two layer models. Although the absolute temperatures and phase angles are subject to some uncertainty, the data are generally inconsistent with the homogeneous model for the lunar surface, but agrees with what would be expected from a layered structure. Author

N66-28657*# Ewen Knight Corp., East Natick, Mass.
A TWO-LAYER MODEL OF THE LUNAR SURFACE
In its Radio Observations of the Moon and Venus at 8.6 mm Wavelength [1965] 13 p refs (See N66-28655 16-30) CFSTI: HC $4.00/MF $1.00

A two layer model of the lunar surface is treated theoretically and an exact analytical solution is obtained for the microwave brightness temperature in terms of the periodic surface temperature. It is found that the time average of the microwave temperature is, even after correction for surface reflectivity, less than the time average of the surface temperature. Further, if the surface layer can be assumed sensibly transparent, the phase lag of maximum microwave temperature behind full moon can be any value whatsoever depending on the thickness of the layer. Author

N66-28660*# Ewen Knight Corp., East Natick, Mass.
ATMOSPHERIC EFFECTS ON CELESTIAL RADIO MEASUREMENTS AT 8.6 MILLIMETERS
Paul M. Kalaghan *In its* Radio Observations of the Moon and Venus at 8.6 mm Wavelength [1965] 33 p refs (See N66-28655 16-30) CFSTI: HC $3.00/MF $1.00

Engineering information on methods of observation and instrument limitation is presented. Areas of consideration include: (1) methods for establishing the focal plane of the secondary reflector; (2) techniques for the cancellation of the atmospheric reradiation component; (3) the effect of the atmosphere in the near field of the antenna aperture (far field approximately 12 miles); (4) determination of antenna beam position; (5) calibration of indicated versus actual radio beam position; (6) attenuation and reradiation attributable to atmospheric gases and associated condensation and precipitation products; and (7) measurement errors introduced by the radome under various observational conditions. A series of measurements were performed to determine the probable magnitude of the error introduced as a result of atmospheric attenuation. Based on these measurements, it was found that the methods of observation and data reduction used in the lunar measurements reduced the effect of atmospheric errors to a negligible degree. D.T.

N66-28767*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
APOLLO MISSION DESCRIPTION
William A. Lee *In its* Contrib. of MSC Personnel to the Manned Lunar Exploration Symp. [1964] p 1–10 (See N66-28766 16-30) CFSTI: HC $3.00/MF $0.75

A typical lunar landing mission is described which provides a total duration of about eight days and a 24-hour stay on the lunar surface. Earth launch and lunar landing phases are described, along with the return lunar launch and earth landing. Translunar trajectories are planned to vary between 62 and 75 hours, whereas return trajectories may range from 85 to 115 hours. The lunar landing area accessible to the Apollo spacecraft is assumed to be a rectangle 90° wide and 10° high, centered on the near-earth face of the moon; but specific landing sites within this area have not been selected. Two crew members will land on the moon, while one member remains in orbit. Numerous illustrations depict the various phases of the proposed mission. M.W.R.

N66-28773*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
MSC RESEARCH ON LUNAR SURFACE EXPERIMENTS
John E. Dornbach *In its* Contrib. of MSC Personnel to the Manned Lunar Exploration Symp. [1964] p 53–63 (See N66-28766 16-30) CFSTI: HC $3.00/MF $0.75

Attention is given to the determination of optimum measurements, experiments, and geologic studies to be made on the lunar surface as well as experimental equipment development and mission support studies. Among the equipment considered are a lunar surface exploration camera, a long-life meteoroid detector–analyzer, an X-ray diffractometer, a solar proton monitor, and a mass spectrometer. Lunar surface simulation models, astronaut training in selenology and geosciences, and power and telemetry studies are mentioned. This overview of lunar surface experiments is discussed in terms of in-house and contracted research projects which are underway or proposed. M.W.R.

N66-28774*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
LUNAR ORBITAL EXPLORATION
James H. Sasser *In its* Contrib. of MSC Personnel to the Manned Lunar Exploration Symp. [1964] p 65–70 (See N66-28766 16-30) CFSTI:: HC $3.00/MF $0.75

Mapping of lunar surfaces and obtaining data on the origin and evolution of the moon are considered in terms of a lunar orbital survey mission. Studies preparatory to and during such a mission are considered in a general review. Various researches underway are mentioned, including: (1) ultraviolet spectroscopy to investigate the feasibility of lunar compositional mapping; (2) photometric, polarimetric, thermal, and dielectric properties of suggested lunar surface materials, and (3) infrared sensors and multispectral photography for lunar compositional analyses. M.W.R.

N66-29398*# National Aeronautics and Space Administration, Washington, D. C.
PLANETARY SPECTRA [SPEKTRY PLANET]
May 1964 16 p refs Transl. into ENGLISH from Priroda (Moscow), no. 6, Jun. 1961 p 39–45
(NASA-TT-F-888) CFSTI: HC $1.00/MF $0.50 CSCL 03B

The analysis of data gathered from the earth by the spectral method of investigation is discussed briefly. It is pointed out that spectroscopic investigations of the planets have developed in three principal directions: study of planetary rotation on the basis of the Doppler shift of spectra lines, photometric study of the continuous spectrum of planets as well as the search for new lines and absorption bands, and study of already known lines and bands. Reports on the results of these investigations are presented in greater detail. A survey of research on the following topics is presented: auroras, and carbon dioxide and water vapor in the Venusian atmosphere; vegetation on Mars; hydrogen and its compounds in the atmospheres of the giant planets; the meteoric nature of Saturn's rings; luminescence and lunar surface color; and the minor planets' spectra. R.L.I.

N66-29476*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
EXTRATERRESTRIAL APPLICATION OF X-RAY DIFFRACTION
H. K. Herglotz 20 Apr. 1966 46 p refs
(NASA-TM-X-53449) CFSTI: HC $2.00/MF $0.50 CSCL 20F

X-ray diffraction provides information about elemental composition and can identify many compounds and minerals. It is, therefore, a promising candidate for the exploration of surfaces of the moon and earth-like planets if apparatus meeting the requirements of this extraterrestrial application can be developed. The fundamentals of X-ray diffraction are described and the difficulties connected with their space application are discussed. Hardware, either specifically designed for space exploration or adaptable for this purpose, are reviewed. Author

N66-29481*# National Aeronautics and Space Administration, Washington, D. C.
SURVEYOR I: A PRELIMINARY REPORT
Jun. 1966 50 p refs
(NASA-SP-126) CFSTI: HC $0.75/MF $0.50 CSCL 22B

This report briefly describes the Surveyor I mission objectives; the launch vehicle, spacecraft, and spacecraft components; the spacecraft trajectory; and its tracking and data acquisition. Emphasis is placed on the scientific data received from Surveyor on lunar surface features. These data show that the terrain surrounding the spacecraft landing site is a gently rolling surface studded with craters ranging from a few centimeters to several hundred meters in diameter and littered with fragmental debris ranging in size from less than 1 mm to more than 1 m. The surface is composed of granular material of a wide size range. Coarse blocks of rock and

smaller fragments are set in a matrix of fine particles too small to be resolved. This material was disturbed by the spacecraft footpads which penetrated to a few centimeters, and is made up of lumps that are probably aggregates of much finer grains. These aggregates show that the fragmental material on the lunar surface is slightly cohesive. It this material is homogeneous to a depth of some tens of centimeters, the soil appears to have a static bearing capacity of about 5 psi. Thermal data indicate that the spacecraft temperature control surfaces are not covered by dust. R.N.A.

N66-29733*# New Mexico Univ., Albuquerque. Bureau of Engineering Research.
EFFECTS OF SURFACE RANDOMNESS OF RADAR BACKSCATTER FROM A SPHERICAL SURFACE
Donald H. Lenhert and Ahmed Erteza [1966] 175 p refs
(Grant NsG-129-61)
(NASA-CR-76016; EE-132) CFSTI: HC $5.00/MF $1.00 CSCL 09F

A vector solution for the scattering of electromagnetic waves from distant rough surfaces was investigated. Integral expressions of the direct- and cross-polarized instantaneous back-scattered power from an arbitrary homogeneous rough sphere were formulated. An approximate solution was obtained for the time-averaged expected values of direct- and cross-polarized received power from a normally distributed surface for the condition that the ratio of standard deviation to correlation distance is much less than one over the square root of the radius of the sphere in wavelengths. Comparison of this solution with experimental data indicates that the moon must have a roughness characterized by a much larger value of this ratio. A rigorous field theory of the pulsed return from a slightly irregular sphere was formulated. The amplitude of the cross-polarized return was found to be a function of both electromagnetic and surface roughness properties. It was felt that this analysis does not give sufficient information for estimating the properties of the lunar surface, but may be useful in solving other cases yielding better estimates. N.E.N.

N66-29738*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
RADAR STUDIES OF THE MOON Quarterly Progress Report No. 2, 1 Feb.–30 Apr. 1966
2 Jun. 1966 57 p refs
(Contract NSR-22-009-106)
(NASA-CR-76012) CFSTI: HC $3.00/MF $0.50 CSCL 03A

Short pulse studies of the lunar surface were made at a 23-cm wavelength, and several conclusions were drawn about the behavior of the lunar surface as a scatterer of radio waves. By using different polarizations for transmission and reception, some of the depolarizing properties were explored. Results indicated that scattering from the center of the disk is largely from regions that are locally smooth on the scale of the wavelength, whereas for an angle of incidence $\phi > 40°$, scattering from rough structure appeared to predominate. Some of the theoretical material pertaining to the effect of shadowing on the backscattering from a rough surface is discussed, and it is concluded that recent theories based on the Kirchhoff theory are erroneous and tend to over-estimate the effect of shadowing. Block diagrams are given of the computer programs required for the Haystack 3.8-cm radar, which will provide radar maps of the lunar surface. Preparations for 8-mm observations were begun by reactivating a 28-ft parabolic antenna system. Determination of the depth of the upper layer of light material on the lunar surface by radio methods is also discussed. L.E.W.

N66-29813# American Meteorological Society, Boston, Mass.
EXPERIMENTAL SPECTROPHOTOMETRIC COMPARISON OF THE SURFACE OF THE MOON AND CERTAIN VOLCANIC DEPOSITS [OPYTY SPERTROFOTOMETRICHESKOGO SOPOSTAVLENIIA POVERKHNOSTI LUNY S NEKOTROYMI VULKANICHESKIMI POKROVAMI]
I. I. Lebedeva Bedford, Mass., AFCRL, Mar. 1966 9 p refs
Transl. into English from Uch. Zap. Leningr. Gos. Univ., Ser. Mat. Nauk (Leningrad), no. 326, 1965 p 99–102
(Contract AF 19(628)-3880)
(T-R-588; TT-66-61162; AD-631970) CFSTI: HC $1.00/MF $0.50

The published data on the spectral reflectivity of the lunar marina and continents are compared to corresponding data for diverse samples of terrestrial rocks from Kamchatka and Kuril Islands. These samples were studied with a photoelectric spectrophotometer (in the region 450–590 millimicron). The spectral reflectivity curves for lapilli, volcanic sand, and brown volcanic scoriae coincide with corresponding curves for the lunar surface in the limits of natural dispersion. Therefore, one can conclude that the presence on the moon of the pyroclastic materials of the type mentioned is possible. Author (TAB)

N66-30344*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
DYNAMICAL BEHAVIOR OF EJECTA FROM THE MOON: PART I: INITIAL CONDITIONS
Barbara E. Shute Apr. 1966 83 p refs
(NASA-TM-X-55521; X-643-66-158) CFSTI: HC $3.00/MF $0.75 CSCL 03B

A reduced form of the patch conic method has been employed to determine the initial orbital elements of a particle launched or ejected from the moon's surface with any arbitrary starting conditions. The reduction was obtained by considering the selenocentric velocity asymptotes. Explicit and tractable analytic functions have been derived for the geocentric and Jacobi energies, angular momentum, standard orbital elements, and conditions for moon-to-earth trajectories. Percents of randomly ejected material which initially strike earth, are in retrograde orbits, or go into heliocentric orbits have been obtained. The results are compared with results obtained by a numerical integration program for several different situations. Author

N66-30394*# Grumman Aircraft Engineering Corp., Bethpage, N. Y.
POLARIMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES Final Report
W. G. Egan, L. L. Smith, and G. C. McCoyd May 1966 264 p refs
(Contract NAS9-4942)
(NASA-CR-76169; RE-250) CFSTI: HC $6.00/MF $1.50 CSCL 03B

An experimental study and a theoretical study consisted of: (1) polarimetric investigation in visual light (0.54μ) of natural specimens having a good photometric match to the moon; (2) polarimetric investigation in visual light of pulverized specimens to determine particle size effects; (3) polarimetric investigation of contrived models combining the above results in blue (0.45μ), green (0.54μ) and infrared (1.0μ) wavelengths; and (4) theoretical analysis of lunar and laboratory data. The over-all conclusion is that the polarization properties of the lunar surface can be produced by a suitable material with a particulate coating of itself. Thus, the surface properties could yield information on the underlying matter and ultimately give information as to the choice of good landing areas for the Apollo mission. The existence of a correlation betwen albedo and polarization on a theoretical basis was confirmed. Author

N66-30438*# Hughes Research Labs., Malibu, Calif.
RESEARCH ON GRAVITATIONAL MASS SENSORS Quarterly Progress Report No. 1, 15 Oct. 1964–14 Jan. 1965
R. L. Forward, Curtis C. Bell, and J. Roger Morris [1965] 95 p refs
(Contract NASw-1035)
(NASA-CR-67369) CFSTI: HC $3.00/MF $0.75 CSCL 17G

The development was begun of a small, lightweight sensor for use on probes and orbiters to measure the mass and mass distribution of extraterrestrial bodies. The major problem area is noise; this noise includes background clutter from external forces and masses other than the one under investigation, external electrical noise and mechanical vibrations, and internal thermal and electronic noise in the sensor and amplifiers. The following conclusions were reached in both theoretical and experimental work. It was shown analytically that radially vibrating structures are not suitable for use as gravitational mass sensors because of a mechanical instability at a rotation frequency equal to 1/2 the vibration frequency. It was experimentally determined that transversely vibrating structures are stable under rotations at 1/2 their vibrations, and therefore, have the basic structural integrity necessary. Finally, in a separate development, it was demonstrated that it is possible to devise and instrument to measure independently the effects of acceleration, rotation, and gravitation—if the Principle of Equivalence is correctly interpreted. D.T.

N66-30602*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
POLARIMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES
W. G. Egan and L. L. Smith Apr. 1966 14 p Presented at the 121st Meeting of the Am. Astron. Soc., NASA, Langley Res. Center, Hampton, Va., 28–31 Mar. 1966
(Contract NAS9-4942)
(NASA-CR-76230; RM-323J) CFSTI: HC $1.00/MF $0.50 CSCL 03B

In an effort to lay the basis for an analytical approach, the polarization properties of volcanic ash and furnace slag were investigated as a function of particle size, albedo, and porosity. These investigations were made on a large scale polarimeter so that coarse specimens could be analyzed. For both samples, the maximum percent polarization (positive) and the corresponding phase angle at zero and 60° viewing angles, the inversion angle, and the minimum percent polarization (negative) varied as a function of porosity and albedo. The best fit to Crisium was achieved with Haleakala volcanic ash with particle sizes between 37 and 88 microns, and furnace slag less than 37 microns; Clavius was fitted with the ash of sizes less than 37 microns, and the furnace slag less than 1 micron. The polarimetric properties of the furnace slag, volcanic ash, and additional laboratory samples were investigated for wavelength dependence. The best color-polarimetric and best visual photometric match to Crisium were obtained with coarse chunks of the volcanic ash topped with less than 1 micron particles of itself. Author

N66-31340# Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.
ISOTHERMS IN THE EQUATORIAL REGION OF THE TOTALLY ECLIPSED MOON
J. M. Saari and R. W. Shorthill Apr. 1966 7 p refs
(DI-82-0530; AD-633033) CFSTI: HC $1.00/MF $0.50

Isothermal contours of the totally eclipsed moon are shown for the equatorial region. Location information is provided by a selenographic grid drawn to 1 degree increments of latitude and longitude. Fifty-five craters which are hot spots are identified by name. Author (TAB)

N66-31385*# Electro-Mechanical Research, Inc., Sarasota, Fla. Telemetry Div.
STUDY OF LUNAR GEOPHYSICAL SURFACE AND SUBSURFACE PROBES FOR APOLLO APPLICATION PROGRAM. VOLUME II: DETAILED TECHNICAL REPORT
W. Knopik et al Jun. 1966 471 p refs
(Contract NAS8-20243)
(NASA-CR-76413) CFSTI: HC $7.17/MF $2.00 CSCL 22A

Presented are the results of a preliminary design study of an integrated geophysical probe system for measuring specific properties of the lunar surface and subsurface during the Apollo Applications lunar surface missions. A survey of geophysical experiments was made and ten subsurface and six surface experiments were selected to provide scientific information relevant to the origin and history of the moon. This report describes in technical detail the instruments that were designed for conducting these experiments. H.S.W.

N66-31418# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
A CONTOUR MAP BASED ON THE SELENODETIC CONTROL SYSTEM OF THE AERONAUTICAL CHART AND INFORMATION CENTER OF THE U.S. AIR FORCE
T. A. Bray and C. L. Goudas Mar. 1966 20 p refs *Its* Math. Note No. 457
(DI-82-0518; AD-633031) CFSTI: HC $1.00/MF $0.50

The control system published in 1965 by the Aeronautical Chart and Information Center (ACIC) has recently been augmented by more than one hundred points, thus making it necessary to perform an analysis of the new enlarged system and construct the corresponding contour map which we present in this paper. This new map exhibits substantial consistence with the one constructed from only the 196 points of the original system, and appears to represent a stronger solution. Author (TAB)

N66-31446*# California Inst. of Tech., Pasadena.
PROCEEDINGS OF THE CALTECH–JPL LUNAR AND PLANETARY CONFERENCE
Harrison Brown, Gordon J. Stanley, Duane O. Muhleman, and Guido Muench, ed. 15 Jun. 1966 357 p refs Conf. held at Calif. Inst. of Tech., Pasadena, 13–18 Sep. 1965 Prepared jointly with JPL
(Contract NSR-05-002-050)
(NASA-CR-76142; JPL-TM-33-266) CFSTI: HC $7.00/MF $1.75 CSCL 03B

Conference papers on lunar and planetary studies for Mars, Jupiter, and Venus are presented. For individual titles see N66-31447–N66-31481.

N66-31447*# California Univ., La Jolla.
OBSERVATIONS ON THE RANGER VIII AND IX PICTURES
Harold C. Urey *In* Calif. Inst. of Tech. Proc. of the Caltech–JPL Lunar and Planetary Conf. 15 Jun. 1966 p 1–23 refs (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

Areas of the lunar surface photographed by camera aboard the Ranger VIII and IX probes are pictured and commented upon. Surface features, such as the nature, distribution, and location of craters and dimples, are used to speculate upon the history of the formation of the surface. Surface density, smooth and rough features, ridges, mountains, and sea areas are discussed. A summary of observations on the Ranger VII photographic series is also made. L.S.

N66-31448*# Arizona Univ., Tucson. Lunar and Planetary Lab.

INTERPRETATION OF THE RANGER RECORDS

Gerard P. Kuiper *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 24-29 refs (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

Records obtained by the Ranger VII, VIII, and IX are interpreted with a view toward answering some basic questions about the nature of the lunar surface. The nature of the mare surface; the existence of major lava flows on the maria (their deposition, solidification, and cooling); the volcanic vents associated with lava channels; the rilles, domes, lineaments, tree-bark structure on the maria; and the many outcroppings are discussed. Also discussed are the primary crater counts; the crater ray deposit fields; the crater ridges; and other lunar surface features. L.S.

N66-31449*# Geological Survey, Flagstaff, Ariz.

PROGRESS IN THE ANALYSIS OF THE FINE STRUCTURE AND GEOLOGY OF THE LUNAR SURFACE FROM THE RANGER VIII AND IX PHOTOGRAPHS

Eugene M. Shoemaker *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 30-31 (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

A report on the progress in reduction and synthesis of the data obtained from the Ranger VIII and IX missions is presented. The photographic data is being used to analyze the fine structure and geology of the lunar surface. The pictures should provide the best material for photogrammetric measurement of the shape of small features on the moon among all of the photographs obtained from the entire Ranger series (with Ranger VII). With the Ranger VIII and IX pictures it is possible to map the geology of selected areas from the photographs at many different scales, ranging from 1:1,000,000 (the scale used in the earth-based telescopic mapping program) up to about 1:10,000 (a scale typically employed for highly detailed geologic mapping on earth). The data should also provide the basis for preliminary planning and evaluation of scientific tasks that may be successfully executed by astronauts in the early landings on the moon of Project Apollo. L.S.

N66-31451*# Scientific Inst. of Radiophysics, Gorky (USSR).

INVESTIGATION OF THE SURFACES OF THE MOON AND PLANETS BY THE THERMAL RADIATION

V. S. Troitsky *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 34-58 refs (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

Experimental and theoretical thermal radiation and radio emission data concerned with the lunar and planetary surfaces are summarized. Mathematical expressions involving the dielectric constants and densities of materials, thermal regimes and parameters; surface radio emission; surface temperatures and temperature gradient to the depth and heat flux out of the body interior; integral radio emission, surface radio emission at the nonperiodic thermal regime (lunar eclipse); surface material microstructure; and chemical (mineralogical nature) composition of surfaces, are presented and discussed. Tabulated data of numerical values of the Fourier expansion terms for surface temperatures in the center of the lunar disk; and of radio emissions of the moon during lunations and eclipse are given. Also discussed is the absorption spectrum of electromagnetic waves in the lunar surface and underlying body, and the results of some radar data regarding the properties of the Venus surface. L.S.

N66-31453*# Academy of Sciences (USSR), Moscow. Schmidt Inst. of Physics of the Earth.

THE STRUCTURE OF THE MOON

B. J. Levin *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 61-76 refs (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

Theories, calculations, and data concerning: (1) the origin of the moon and the tidal evolution of the earth-moon system, (2) the history of lunar bombardment, (3) the lunar thermal history, (4) the shape of the moon, (5) density distribution of the lunar body and crust, (6) the chemical composition of lunar material (the question of frozen and nonfrozen volatiles and of hydrated silicates is submitted), and (7) the history of the lunar atmosphere, as put together from the literature, are presented and discussed. L.S.

N66-31454*# California Univ., Los Angeles.

ON THE INTERNAL CONSTITUTION AND ORIGIN OF THE MOON

Gordon J. F. Mac Donald *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 77-83 refs (See N66-32446 18-30) CFSTI: HC $8.00/MF $1.75

Data on the orbital and rotational motion of the lunar body; the mass and mean density of the moon; interpretation of the moon's moment of inertia; thermal constitution and distribution considerations; and other evidence, are used to draw inferences regarding the internal structure of the moon. Evidence on hand seems to support the view of an inhomogeneous, nondifferentiated moon. The relevance of dynamical arguments to the question of how the moon may have formed is considered, and a model of formation is suggested. With further data (such as seismic observations and determination of the lunar gravitational field) it is expected that more sophisticated models will be made. L.S.

N66-31455*# California Inst. of Tech., Pasadena.

THE INTERNAL STRUCTURE OF THE MOON AND THE TERRESTRIAL PLANETS

Don L. Anderson and Robert L. Kovach (Stanford Univ.) *In its* Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 84-91 (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

The hypothesis that differences in the mean densities of the terrestrial planets account for inhomogeneity in this part of solar system is re-examined in the light of new information regarding the distribution of density in the interior of the Earth. The iron in Mars may be more evenly distributed than in Earth, but Mars may still not differ from the Earth in overall composition. It is possible to design models for Mars and Venus that have the same uncompressed density as the Earth and that satisfy the available data concerning these planets, without assuming that the Earth's core is a phase change of the silicate mantle. Thermal history calculations for computing the densities of planetary bodies with depth, and which show whether the body is differentiated or not, are presented and discussed. An equation of state that is appropriate for the Earth predicts a density decreasing with depth in the lunar interior, thereby giving a high moment of inertia. Seismic travel-time curves ad periods of free oscillation were also computed for the moon model. Several graphs depicting the calculations described, are included. L.S.

N66-31456*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LUNAR STRUCTURE AS DEDUCED FROM MUONG NONG TEKTITES
J. A. O'Keefe and I. Adler *In* Calif. Inst. of Tech. Proc. of the Caltech-JPL Lunar and Planetary Conf. 15 Jun. 1966 p 92–101 refs (See N66-31446 18-30) CFSTI: HC $7.00/MF $1.75

The Muong Nong tektites, found chiefly in Thailand and Indo-China, are discussed with respect to the morphology and structure of lunar craters. These tektites have characteristic structures similar to those seen in most tektites, but the Muong material structure is arranged in parallel layers and is accompanied by a shimmering appearance within each layer. Chemical analysis shows them to be almost identical with splash-form tektite types which, when examined as whole bodies between crossed nicols, show a pattern of strain birefringence. This indicates that splash-form types cooled as a unit; however no such overall strain pattern is associated with the Muong material. This suggests that Muong tektites, generally found in large associations, are more primitive than other types. Angular voids (spaces between grains) in the crystalline structure imply that these tektites were never thoroughly mixed. Various data and microphotograph studies are discussed which lead to the conclusion that the Muong material was glass or finely crystalline before impact with earth took place. This implies that the impact took place in space. As these tektites are found inbedded in lunar surface material formed by natural volcanic ash, the findings can be applied to studying lunar crater structures. L.S.

N66-31780# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
A PRELIMINARY ANALYSIS OF THE MECHANICAL PROPERTIES OF POSTULATED LUNAR VESICULAR ROCKS
L. L. Karafiath Jun. 1966 32 p refs
(RM-328)

A preliminary theoretical evaluation of the mechanical properties of vesicular materials in relationship with their porosity is presented, and the mechanical properties of postulated lunar vesicular rocks with respect to the planned engineering operations on the moon are assessed. Author

N66-31891*# Consultants and Designers, Inc., Arlington, Va.
SOVIET PRESS COMMUNIQUES AND THE PRAVDA EDITORIAL ON "LUNAR-9" SOFT LANDING ON THE MOON
10 Feb. 1966 21 p Transl. into ENGLISH from Pravda and Komsomol'skaya Pravda (Moscow), 4–5 Feb. 1966
(Contract NAS5-3760)
(NASA-CR-76466; ST-PR-10445) CFSTI: HC $1.00/MF $0.50 CSCL 22B

The Luna-9 soft landing on the moon is reported; details are given on radio transmission sessions, and the telemetry system. Some recorded photographs showing geographic details of the lunar surface are included. The lunar station itself, its engine system, and instrument compartments are listed. The schematized flight depicts: carrier rocket placing the probe in orbit, the rocket block firing for acceleration into the lunar flight trajectory, and subsequent trajectory correction. Parameters of the orbit are briefly outlined, and the exact marine landing site is indicated. R.Ll.

N66-32032*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
THE RELATION OF TEKTITES TO LUNAR IGNEOUS ACTIVITY
Paul D. Lowman, Jr. *In its* Publ. of Goddard Space Flight Center, 1963, Vol. I [1963] p 1215–1227 refs (See N66-32006 18-30) GPO: HC $9.75; CFSTI: MF $7.50

The theory that tektites are of lunar origin has frequently been criticized on the grounds that rocks of this chemical composition could not have been formed on the moon. The purpose of this paper is to show that tecktites may have been derived from silicis igneous rocks, specifically rhyolitic tuffs, forming the upper layers of the maria. The essentially igneous nature of tektites is indicated by their bulk composition, their restricted compositional range, and the high probability that they have not been derived from sedimentary rocks by random processes such as meteoritic impact. The differences between tektites and normal igneous rocks probably reflect their formation by extremely high temperature fusion of previously solid igneous rock. It is shown that if the moon originally had a chondritic composition, the fusion curve of the lunar material should intersect the thermal gradients computed at the present time at 400 to 500 km depth, depending on the slope of the fusion curve, even if the moon had originally been at 0°C. Additional heat sources such as the kinetic energy of accretion and capture-induced internal friction would probably have raised the temperature well above the cold moon gradient. Magmas generated by partial fusion of the assumed chondritic material should be basaltic. It is proposed that the maria are the lunar equivalents of terrestrial lopoliths such as the Bushveld and Sudbury complexes. Author

N66-32110*# Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.
EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE
Eighth Quarterly Progress Report and Second Year Summary, 1 Apr.–30 Jun. 1966
J. A. Ryan 26 Jun. 1964 48 p refs
(Contract NAS7-307)
(NASA-CR-76430; DAC-59288) CFSTI: HC $2.00/MF $0.50 CSCL 08G

The ultra-high vacuum adhesion of silicates as related to the lunar surface was studied. Silicates, such as may exist at the lunar surface, were contacted with silicates and engineering materials which may be used at the lunar surface. Adhesion force was measured as a function of load force, crystalline orientation, surface roughness, and type of forepump used. Two types of adhesional behavior were found for the air-formed surfaces. The first appeared only under load, increasing rapidly with increasing load; was of relatively large magnitude; and was present only at ultra-high vacuum. Extensive surface damage and material transfer also were noted. This behavior is caused by the action of the normal silicate atomic bonding forces. The second type was present at zero load, showed little load dependence, was of relatively low magnitude, persisted in dry nitrogen, and did not produce surface damage or material transfer. This behavior is most probably caused by the action of the dispersion forces. For the vacuum-cleaved samples, the adhesion was much larger than that observed for the air-formed samples. A strong long-range attractive force, indicative of considerable surface charging, was noted. The results indicate that the primary contributor to the observed adhesion is the normal silicate bonding forces, and also that the long range force is caused by a statistical charge separation produced during cleavage. Results indicate that silicate adhesion can be the major factor in determining the behavior of lunar materials and that its precise role is critically dependent upon the nature of the contacting surfaces. Author

N66-32193# Kyoto Univ. (Japan).
PHOTOGRAPHIC ATLAS OF THE MOON, SECOND EDITION, 1964
S. Miyamoto and A. Hattori, ed. 1964 141 p Contrib. from Inst. of Astrophysics and Kwasan Obs. No. 137
CFSTI: HC $3.00/MF $1.00

Very good quality photographs of the lunar surface, obtained with cameras attached to the Cooke refractor and Tsugami reflector telescopes are presented. Descriptions of the telescopes and their cameras are given. The lunar surface was divided into 29 districts, the last 8 sections of which are libratory regions. For each section, morning, evening, and high sun photographs were selected. Maps for illustration are omitted. The purpose of this atlas is for the study of large scale geological features of the lunar crust, and not for lunar geodesy. L.S.

N66-32298*# Harvard Coll. Observatory, Cambridge, Mass.
A STUDY OF THERMAL RESPONSE OF THE LUNAR SURFACE AT THE LANDING SITE DURING THE DESCENT OF THE LUNAR EXCURSION MODULE (LEM)
Jerome T. Holland and Hector C. Ingrao 1 Apr. 1966 58 p refs Prepared for Arthur D. Little, Inc. and NASA
(Grant NsG-64-60)
(NASA-CR-76648) CFSTI: HC $2.50/MF $0.50 CSCL 03B

This report analyzes the thermal response of the lunar surface at the landing site due to the radiative and convective heat transfer from the LEM exhaust nozzle. A computer program has been written to analyze the thermal transients as a function of (1) the thermal model of the lunar surface materials; (2) depth beneath the lunar surface; (3) distance from the touchdown point. The physical meaning of the answers obtained in our analysis depends on how accurate the heat transfer parameters are for the assumed model, during the LEM descent. Therefore we prefer to stress the method of analysis rather than the numerical conclusions. Author

N66-32300*# Bellcomm, Inc., Washington, D. C.
PHOTOMETRY AND POLARIMETRY OF THE MOON AND THEIR RELATIONSHIP TO THE PHYSICAL PROPERTIES OF THE LUNAR SURFACE Summary
C. A. Pearse 23 Aug. 1963 8 p
(Contract NASw-417)
(NASA-CR-76695; TR-63-211-7) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Experimental and theoretical information relating to the photometry of the moon is reviewed, with emphasis given to the salient lunar light reflecting properties which are controlled by the exact nature of the lunar surface microrelief. A lunar covering surface model is briefly described, and compared to conclusions based on photometric data. Certain types of information that cannot be obtained from an analysis of lunar photometric, polarimetric, and colorimetric data are listed. It was concluded that the lunar surface is covered, at least to millimeter depth, with an intricate matrix made up of small adhesive grains, probably resulting from pulverization of lunar surface material by micrometeoroid bombardment. L.E.W.

N66-32568# Library of Congress, Washington, D. C. Aerospace Technology Div.
SURFACE CHARACTERISTICS OF THE MOON, MARS, AND VENUS Annotated Bibliography
Joseph Javis and Daniel W. Michaels 16 May 1966 72 p refs
(ATD-66-53)

This annotated bibliography was compiled from Soviet-Satellite open sources published 1963–1966. It is the second report in a continuing series indicative of Soviet-bloc research of the surface characteristics of Mars, Venus, and the Moon with reference to light polarization and albedo measurement techniques and to radioastronomical investigations. The 110 bibliographic entries are listed alphabetically by author in four sections: I. The Moon (58 entries); II. Mars (28 entries); III. Venus (18 entries); IV. General (6 entries). An Author Index is included at the end of the report. Other information included: Photography of celestial bodies, photogrammetry, and photointerpretation in space investigations; usual formation on Venus; radar observations of Venus; Martian canals; Mars satellites; volcanic activity on Mars; colorimetric comparison of asteroids and terrestrial rocks. Author

N66-32612*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
ELECTRICAL POWER SYSTEMS STUDIES AT MSEC
Edward E. Dungan *In its* Power Systems Res. at MSFC 1965 p 31–44 refs (See N66-32606 18-03) CFSTI: HC $2.50/MF $0.75

Electrical power systems applicable to earth orbital and to lunar surface missions are discussed. Saturn Instrument Unit lifetime extensions will require fuel cells and/or radioisotopes for primary power. Lunar surface vehicles such as the Mobile Laboratory (MOLAB) will use fuel cells that must be optimized for mass savings. Two computer programs are discussed and one is described. Author

N66-32956*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LUNAR STRUCTURES AS DEDUCED FROM MUONG NONG TEKTITES
J. A. O'Keefe and I. Adler Washington, NASA, Aug. 1966 16 p refs
(NASA-TN-D-3564) CFSTI: HC $1.00/MF $0.50 CSCL 03B

From previous work, it is generally believed that tektites are derived either from terrestrial sedimentary rocks or from the moon. The Muong Nong tektites contain angular voids, an indication that they have never been completely melted. Microprobe studies of the voids indicate that they are chemically homogeneous, which seems to rule out the possibility of the tektites' having a terrestrial sedimentary origin and to indicate that they are from fragmental glass and of lunar origin. This conclusion is reinforced by Walter's discovery of coesite in tektites; it is interpreted in the light of theoretical studies of lunar ash flows, and the result is compared with the known lunar topography. Finally, the possibility that the lunar red spots may be lightning-generated during a small ash flow is noted. Author

N66-32960*# Texaco Experiment, Inc., Richmond, Va.
LUNAR GEOPHYSICAL SURFACE AND SUBSURFACE PROBES FOR APOLLO APPLICATIONS PROGRAM: VOLUME I: DETAILED TECHNICAL REPORT Final Report
R. H. Clinard, Jr. 27 May 1966 516 p refs
(Contract NAS8-20085)
(NASA-CR-76721; EXP-452, Vol. I; TP-277, Vol. I) CFSTI: HC $4.66/MF $2.50 CSCL 22A

A study has been carried out to determine the optimum integrated instrument probes to be used for manned lunar exploration with the Apollo Applications Program. A lunar probes system is recommended consisting of: an optimum subsurface

probe, a subsurface neutron–gamma probe, a subsurface television probe, an integrated surface probe, a supporting electronics package, a deployment and cable assembly, and an acoustic source holder. This system is described in detail with the justifications, instruments characteristics, and operations requirement of the selected experiments given. Information is also included on experiments considered in the study, which do not appear in the recommended system. Author

N66-32961*# Texaco Experiment, Inc., Richmond, Va.
LUNAR SURFACE AND SUBSURFACE PROBES FOR APOLLO APPLICATIONS PROGRAM. VOLUME II: SUMMARY TECHNICAL REPORT Final Report
R. H. Clinard, Jr. 27 May 1966 109 p
(Contract NAS8-20085)
(NASA-CR-76720; EXP-462, Vol. II; TP-277, Vol. II) CFSTI: HC $3.00/MF $0.75 CSCL 22A

A lunar probes system is recommended that consists of: an optimum subsurface probe, a subsurface neutron–gamma probe, a subsurface television probe, an integrated surface probe, a supporting electronics package, a deployment and cable assembly, and an acoustic source holder. This system is described in detail, including the justifications, instrument characteristics, and operational requirements of the selected experiments. A listing is also included of experiments considered in the study which do not appear in the recommended system. Non-functional mockup hardware of the recommended probes was constructed and submitted to NASA for use in system integration studies and time-and-motion-study testing. Author

N66-33167*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
INSTRUMENTATION FOR INVESTIGATING THE PHYSICAL PROPERTIES OF THE LUNAR SURFACE
Alfred G. Beswick Pittsburgh, Pa., ISA [1964] 21 p refs Presented at the 19th Ann. ISA Conf. and Exhibit, N. Y., 12–15 Oct. 1964
(NASA-TM-X-54872) CFSTI: HC $1.00/MF $0.50 CSCL 03A

One of the problems confronting the current effort to explore the moon is the physical condition of the lunar surface, particularly with regard to its bearing strength with respect to spacecraft landings. Researchers have found that a good idea as to the hardness, bearing strength, and penetrability of the lunar surface can be gained from analysis of the deceleration time history resulting from the impact of deceleration measuring instruments, i.e., impact accelerometers. The accelerometers are embodied in a structure called a pentrometer which also houses a radio telemeter. The penetrometer thus has the capability of transmitting the impact information to a remote receiver. The instrumentation concepts and details of two types of penetrometers are described. Typical applications of how such instrumentation might be employed to investigate lunar or planetary surface conditions with various spacecraft are presented. Author

N66-33169*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
LUNAR DIFFERENTIATION PROCESSES
Louis S. Walter [1964] 21 p refs Submitted for Publication
(NASA-TM-X-54903) CFSTI: HC $1.00/MF $0.50 CSCL 03B

This discussion begins with the assumption that the buildup of radiogenic heat in the moon has resulted in ubiquitous magma generation. Such igneous activity should have occurred sporadically over the lunar surface resulting in the differentiation of a lunar crust. The differentiation concentrated the radioisotopes in the more acidic crustal fraction which tended to increase the surface volcanic activity and further degassed and dehydrated the surficial rocks. However, loss of volatiles had the opposite effect of decreasing magma generation. The lack of water and sedimentary recycling may be why the moon is a cold body since volcanic activity may have been greatly curtailed in the recent selenological past. The products of the most recent stages of lunar magma generation are dealt with. Three factors affecting terrestrial magmatic trends, studied in the laboratory and in the field, are discussed in terms of their effect on lunar differentiation trends. Two factors, the lower pressure gradient with depth and the supposed water deficiency of the moon, would tend to cause lunar magmas to be acidic or silica rich. An extremely low abundance or fugacity of oxygen would tend to have the same effect. R.N.A.

N66-33526*# Israel Program for Scientific Translations, Ltd., Jerusalem.
PHYSICS OF THE MOON AND THE PLANETS
I. K. Koval', ed. 1966 116 p refs Transl. into ENGLISH of "Fizika Luny i Planet" Kiev, Naukova Dumka, 1964 Prepared for NASA and NSF
(NASA-TT-F-382; TT-66-51019) CFSTI: HC $4.00/MF $1.00 CSCL 03B

CONTENTS:

N66-33527*# Israel Programs for Scientific Translations, Ltd., Jerusalem.
POLYCHROMATIC POLARIMETRY OF SOME LUNAR REGIONS
V. V. Avramchuk *In its* Phys. of the Moon and the Planets 1966 p 1–10 refs (See N66-33526 19-30) CFSTI: HC $4.00/MF $1.00

Umov's effect for fine dispersion media assumes that as the specific absorptivity (β) of the medium increases, the significance of higher order scattering is rapidly reduced. As β increases, the spectral composition and degree of polarization of reflected light will vary, if it is assumed that no regular phase interface exists; another effect exists in the presence of a phase interface, that is there is a variation of the intensity ratio for the light reflected directly from the intersurface and the light scattered by the dispersed medium. Polarization observations are reported for determining the optical characteristics of lunar material. A variation of degree of polarization with wavelength is found at phases +12° to +13°. The degree of positive polarization varies almost monotonically and increases sharply in the ultraviolet for Plato, Grimaldi, and Otto Struve. Tycho and Copernicus have a degree of polarization which varies negligibly with wavelength in the 420 to 600 mμ range and increases only in the ultraviolet. A formula is given to show the relationship between the maximum degree of polarization and the albedo in narrow spectral regions. M.W.R.

N66-33528*# Israel Program for Scientific Translations, Ltd., Jerusalem.
SPECTROPHOTOMETRY OF SOME LUNAR OBJECTS
M. N. Mironova *In its* Phys. of the Moon and the Planets 1966 p 11–22 refs (See N66-33526 19-30) CFSTI: HC $4.00/MF $1.00

Various lunar craters were studied by obtaining spectral brightness coefficients and comparing the spectra of various lunar objects. Examination of about 500 spectrograms revealed that no gas efflux was observed in the following craters: Alhazen, Alphonsus, Aristarchus, Arzachel, Herodotus, Hyginus, Linné, Messier, Plato, Schickard, and Tycho. Spectral brightness curves indicate that the surfaces of these craters are covered with rocks that have spectral characteristics like basalt tuff. Floor, central peak, and walls do not differ much in spectral reflectivity; the greatest difference observed was between the yellowness indices of the central floor and peak of Alphonsus. The surface of Aristarchus has rocks with a luminescent band similar to that of scheelite; this luminescence is attributed to ultraviolet radiation from the sun and solar corpuscular flow. M.W.R.

N66-33529*# Israel Program for Scientific Translations, Ltd., Jerusalem.
SPECTRAL STUDIES OF THE LUNAR SURFACE
A. N. Sergeeva *In its* Phys. of the Moon and the Planets 1966 p 23–33 refs (See N66-33526 19-30) CFSTI: HC $4.00/MF $1.00

More than 200 lunar features were observed from the processing of 56 spectrograms in order to detect color contrasts for these different features. At each wavelength, deviations were calculated of the intensities of these lunar features from the intensity of the standard area or from mean intensity of all lunar features. These results are presented in 15 tables, each of which gives the wavelengths of the microphotometric sections and the color shadings of the different lunar formations expressed as percentages of the intensity of the standard area. Four spectra appear on each table, and from two to seven lunar features are distinguishable in each spectrum. Relative intensity deviations range from less than 10% to 18%; and since these deviations are comparatively small, it is concluded that the actual color contrasts of the lunar features are too slight to be detected by photographic photometry. M.W.R.

N66-34195# Arizona Univ., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 4, PART 2
1965 57 p refs
(Contract AF 19(628)-4332)
(AD-634501) CFSTI: HC $3.00/MF $0.75

CONTENTS:

1. THE REDUCTION OF MEASURES FOR POSITION ON A SINGLE LUNAR PHOTOGRAPH D. W. G. Arthur 4 p refs (See N66-34196 20-30)
2. SELENODETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 1170 D. W. G. Arthur 44 p refs (See N66-34197 20-30)
3. THE COMPUTATION OF SELENODETIC COORDINATES USING THE LIBRATIONS D. W. G. Arthur 8 p refs (See N66-34198 20-30)

N66-34196# Arizona Univ., Tucson.
THE REDUCTION OF MEASURES FOR POSITION ON A SINGLE LUNAR PHOTOGRAPH
D. W. G. Arthur *In its* Commun. of the Lunar and Planetary Lab., Vol. 4, Pt. 2 1965 4 p refs *Its* Commun. No. 60 (See N66-34195 20-30) CFSTI: HC $3.00/MF $0.75

This paper details the computational methods used to convert raw measures on lunar photographs into rectangular coordinates that are free of refraction. Author

N66-34197# Arizona Univ., Tucson.
SELENODETIC MEASURES ON YERKES LUNAR PHOTOGRAPH NO. 1170
D. W. G. Arthur *In its* Commun. of the Lunar and Planetary Lab., Vol. 4, Pt. 2 1965 4 p refs *Its* Commun. No. 61 (See N66-34195 20-30) CFSTI: HC $3.00/MF $0.75

Details are given of 1538 coordinate measurements on Yerkes lunar photograph No. 1170. The catalog lists the refraction-free photographic coordinates of 1099 points on the disk. The selenographic coordinates of the projections of these on the spherical lunar datum are also listed. The limb of this photograph is represented by the refraction-free rectangular and polar coordinates of 439 points on the profile. Author

N66-34198# Arizona Univ., Tucson.
THE COMPUTATION OF SELENODETIC COORDINATES USING THE LIBRATIONS
D. W. G. Arthur *In its* Commun. of the Lunar and Planetary Lab., Vol. 4, Pt. 2, 1965 8 p refs *Its* Commun. No. 62 (See N66-34195 20-30) CFSTI: HC $3.00/MF $0.75

Details are given of the method for combining measures on different lunar photographs, using the librations, to compute selenodetic coordinates. Published methods are critically examined, and the correct treatment of pseudo-observation is outlined. A first-order treatment of the error theory for a selenodetic positions is derived from the method of combining plates. Author

N66-34284# Library of Congress, Washington, D. C. Aerospace Technology Div.
SOVIET LONG-RANGE SPACE-EXPLORATION PROGRAM
Surveys of Communist World Scientific and Technical Literature
Vladimir E. Mutschall 16 Feb. 1966 36 p refs Analytical Surv.
(ATD-66-18; AD-633962) CFSTI: HC $2.00/MF $0.50

This analytical survey is based on Soviet open sources published 1956–1965. It is one of a series of reports dealing with the soviet long-range space-exploration program and is concerned, in particular, with lunar surface research. Information not directly related to this subject has been included because of its broad implications for study in this field. This report may prove useful to lunar mission planners, both those concerned with the purely scientific aspects of the moon's surface and immediate subsurface and those involved in the development of lunar exploration vehicles and in the establishment of permanent lunar bases. Information is divided as follows: photometric observations; spectral observations; measurement of lunar temperatures; the meteor slag theory; interpretation of lunar craters; lunar-seismicity; radio echo studies; lunar atmosphere. The main purpose of this report is to present an up-to-date summary of the current state of soviet knowledge concerning the surface of the moon. The question of lunar topography is of obvious importance to the landing of instrument packages and manned vehicles on the moon. Every major aspect of the current lunar research program has been considered and all pertinent evidence available from Soviet. TAB

N66-34352# Army Dept., Washington, D. C. Office of the Chief of Engineers.
LUNAR DEVELOPMENTAL HISTORY AND ITS ENGINEERING IMPLICATIONS Final Report, Jun. 1964–Jul. 1965
Bruce M. Hall Jun. 1966 44 p refs
(TN-66-201; AD-633784) CFSTI: HC $2.00/MF $0.50

Observed data and current theories were studied to explain the selonologic character and engineering properties of the lunar surface. Formation of the moon by accretion of cold particles, followed by internal heating, complete melting, magmatic differentiation and planetary cooling and degassing is postulated. Principal lunar surface features resulted from infall of space debris, magma flows, crustal deformation and surface erosion by sputtering, meteoroid impact and ejecta from primary impacts. Evidence is presented to support the hypothesis, engineering properties of the lunar surface are postulated for an average marial topographic province. The lunar surface is composed principally of granular material varying as to granular gradation. Soil bearing strength, compaction, adhesion, excavation procedures, trafficability, dust propogation and surface temperatures are considered. Similar engineering data for the highlands may not be induced at this time because of their more heterogeneous character. Author (TAB)

N66-34528# Boeing Scientific Research Labs., Seattle. Geo-Astrophysics Lab.
ON THE NONUNIFORM COOLING BEHAVIOR OF THE ECLIPSED MOON
D. F. Winter May 1966 10 p refs
(DI-82-0531; AD-634303) CFSTI: HC $1.00/MF $0.50

Anomalous cooling of certain regions of the moon during an eclipse may be attributable to preferential surface roughness on a centimeter scale. Several arguments are presented in support of this hypothesis and a quantitative illustration is displayed. Implications with regard to lunar crater evolution are discussed briefly. Author (TAB)

N66-34806# Illinois Univ., Urbana. Electrical Engineering Research Lab.
IONOSPHERIC RESEARCH Tenth Quarterly Progress Report, 1 Jan.–31 Mar. 1966
H. D. Webb Jun. 1966 58 p refs
(Contract DA-36-039-AMC-03703(E))
(ECOM-03703-10; AD-634729) CFSTI: HC $3.00/MF $0.75

Moon-reflected signals were received on 150.6 mc and 413.25 mc on 36 days during the quarter. Data have not been analyzed for correlations with magnetic and solar activity which occurred during the times of observation. A phase-lock receiver, designed to stay tuned to the incoming moon-reflected signals at 150.6 mc, is working well. Small errors in antenna position, both at the transmitter and at the receiver, lead to errors in Faraday rotation angle at 413.25 cm, which can cause erroneous resolution of the $n \times 180°$ ambiguity. When observations are made for one or two hour periods these errors tend to cancel. A thesis for the M.S. degree dealing with the design of circularly polarized antennas for 150 mc, is appended. Author (TAB)

N66-35017*# National Aeronautics and Space Administration, Washington, D. C.
NASA CONFERENCE ON CELESTIAL MECHANICS
Joseph W. Siry et al [1963] 26 p Proc. of conf. held at the Naval Obs., 10–11 Jan. 1963
(NASA-TM-X-57856) CFSTI: HC $2.00/MF $0.50 CSCL 03C

Abstracts are given of the topics discussed at the NASA conference on celestial mechanics, and the discussions concerning these topics are included. The subjects covered include space needs and techniques, geodetic and selenodetic problems, astronomical and computational problems, mathematical problems and periodic orbits, and relativity and gravitation. L.E.W.

N66-35221*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
AERO-ASTRODYNAMICS RESEARCH REVIEW NO. 4, JULY 1–DECEMBER 31, 1965
William D. Murphree, ed. 1 Apr. 1966 130 p refs
(NASA-TM-X-53462) CFSTI: HC $3.00/MF $1.00 CSCL 22A

A review of research in the following areas is reported: Aerothermodynamics, Fluid Mechanics, Instrumentation, Orbit Theory and Prediction, Selenography, Space Environment, and Structural Dynamics. Cited are papers on: convective heat transfer in turbulent, supersonic base flow; fluid mechanics regimes related to propellant oscillations under low gravity conditions; remote sensing with optical cross correlation methods; the application of the Q-ball angle of attack transducer to large space vehicles; a solution to a problem of orbit determination with possible applicability to the abort guidance problem; a lunar maria terrain model for use in lunar surface vehicle; revised meteoroid flux and puncture models; radiation pressure and its effects on satellite motion; the dynamic approach of fuel sloshing problems in a space vehicle; and wind penetration effects on flight simulations. S.C.W.

N66-35508*# Grumman Aircraft Engineering Corp., Bethpage, N. Y.
GEOMETRY OF BACKSCATTERING SURFACES AS APPLIED TO THE MOON
J. D. Halajian *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources 1965 p 78–123 refs (See N66-35506 21-30)
(Contract NAS9-3182) CFSTI: HC $8.50/MF $2.75

The relationship between the photometric and geometric properties of the lunar surface is studied by means of artificial models that lend themselves readily to controlled manipulation and analysis. Composite models consisting of dust covered geometric solids permit the study of the relative contribution of micro- and macro-roughnesses (including the effect of slopes) on the total backscatter. A simple, i.e., dust-free, model built by means of thumb tacks helps to demonstrate that shadowing on and within

a dark porous structure can primarily be responsible for the backscattering exhibited by the lunar surface and that both quasi-horizontal and quasi-vertical members having a well-defined proportion and spacing appear to be necessary components of a lunar photometric model. Simple models of the thumb tacks variety help the experimenter to interpret the lunar data or their terrestrial analogs in terms of relevant properties rather than in terms of generic names (i.e., dust, cinder, slag, etc.) that often confuse the issue. Author

N66-35510*# Pennsylvania State Univ., University Park. Materials Research Lab.

LUNAR WATER RESOURCES

Jon N. Weber, G. W. Brindley, Rustum Roy, and J. H. Sharp 29 Oct. 1965 *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources 1965 p 194–233 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

If a substance could be found on the moon from which hydrogen and oxygen could be obtained, the use of the moon as a refueling station for hydrogen fueled rockets would greatly enhance exploratory expeditions into deep space. The value of any given mineral or rock will depend on the probability of finding the substance in the vicinity of the landing area, the abundance of the mineral or rock, the amount of water contained, and the difficulty of extracting the water. These factors are used as a basis in evaluating possible sources of lunar water. The sources considered include basaltic and granitic rocks, serpentine and other hydrated minerals, and water in the solid phase trapped in permanently shaded cold spots in the polar regions. It is stated that severe limitations are imposed on the design of a program to use lunar materials for water supply because information concerning the chemical composition and distribution of minerals on the lunar surface are not yet available, and the available data on the thermodynamics and kinetics of water evolution from minerals are not directly applicable to lunar surface environments. H.S.W.

N66-35511*# Northrop Space Labs., Hawthorne, Calif.

A NOTE ON PETROLOGIC PROCESSES AND LUNAR LOGISTICS

Emanuel Azmon *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources 1965 p 234-243 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

Utilization of lunar natural resources for support of human activities is examined through a study of petrologic processes in igneous rocks. Four groups of variables are formed to establish bulk properties: composition, temperature, pressure, and history. Rock forming systems are subdivided into 10 sets of igneous rocks that can attain a definite genetic state. A typical genesis diagram is included for gabbro, which shows the pressure and temperature of formation of the 10 genetic states. Photomicrographs of heat-treated gabbro illustrate the good correlation between the physical parameters (the variables) that define a genetic state and the recognized petrologic characteristics of the rock. Benefits derived from the knowledge of processes and conditions for the formation of igneous rocks are listed as the ability to generate rock end products at will and to determine the provenance of a natural rock. S.P.

N66-35512*# Little (Arthur D.), Inc., Cambridge, Mass.

CRYOGENIC STORAGE ON THE MOON

Peter F. Strong, Peter E. Glaser, Frank Gabron, and Carrol H. Sox *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 244–268 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

To assess the problems anticipated in storing cryogenic fluids on the surface of the moon for extended periods, methods are presented for estimating heat inputs to a storage vessel exposed to the lunar environment and for quantitatively predicting the expected boil-off losses. The radiation interchange with the lunar surface was identified in terms of the observed lunar surface photometric properties and the results were compared with radiation from a surface obeying Lambert's law. The lunar surface characteristics of importance to cryogenic storage, the selection of appropriate support concepts, the performance of highly effective thermal insulations, and the treatment of piping penetrations to reduce performance degradations are discussed. Results are presented of analyses of the heat exchange for the computation of environment heat of fluxes and the boil-off rate is estimated for a specific cryogenic vessel design. Author

N66-35513*# Naval Ordnance Test Station, China Lake, Calif.

LUNAR GEOTHERMAL POWER: SOME PROBLEMS AND POTENTIALS

Carl F. Austin, J. Kenneth Pringle, and Richard D. Fulmer *In* AF Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 269–288 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

Power from geothermal deposits on earth is an established fact, with plant capacities ranging from a few kilowatts to several hundred megawatts. The increasing evidence for contemporary volcanic and fumarolic activity on the moon lends strong support to the validity of the concepts of utilizing geothermal fluids as a source of lunar power. Geothermal energy, whatever the size of installation desired, will probably not be an energy source during early exploratory operations, because of the inherent uncertainty in developing natural resources. On the other hand, the attractiveness of geothermal concepts with their abundant potential for byproduct fuel and life-support production, plus the potential for large continuous power outputs, suggests that the location and testing of areas of geothermal potential should be an early goal for lunar exploration efforts. This paper describes the chemical and structural properties of geothermal deposits and outlines the differences expected between lunar and terrestrial deposits and their surface expressions. Author

N66-35514*# North American Aviation, Inc., Downey, Calif. Space and Information Systems Div.

A PRELIMINARY LOGISTICS BURDEN MODEL FOR THE PRODUCTION OF LUNAR ORES

Carl B. Hayward 15 Aug. 1964 *In* Acad. Proc. of the Working Group on Extraterrest. Resources [1965] p 289–311 refs (See N66-35506 21-30) CFSTI: HC $8.50/MF $2.75

This report of a preliminary study attempts to establish a logistic burden model for lunar mining and ore dressing to support the production of water, oxygen, and other logistically important life-support and propellant substances from lunar rock. Mining methods and equipment are sensitive to many factors, and perhaps the most important of these is the required production rate. This study, therefore, is based on system production ratings of ten and one hundred times a modular unit (M) equivalent to 9 lb/hr of water or 8 lb/hr of oxygen. The mining concept upon which the study is based involves the use of chemical explosives and one or more special mining machines which, with one exception, are all vehicular in nature. Initial mining efforts are presumed to be surface operation. Conclusions include the logistic burden rates for capital equipment, consumable supplies, electric power, and manpower—all expressed as a function of the production order of magnitude. Author

N66-35596*# Geological Survey, Washington, D. C.
ASTROGEOLOGIC STUDIES. PART D: STUDIES FOR SPACE FLIGHT PROGRAM Annual Progress Report, Aug. 25, 1962–Jul. 1, 1963
May 1964 141 p refs
(NASA Order R-66)
(NASA-CR-58623) CFSTI: HC $4.00/MF $1.00 CSCL 22A

CONTENTS:

N66-35597*# Geological Survey, Washington, D. C.
A PHOTOMETRIC TECHNIQUE FOR MEASUREMENT OF LUNAR SLOPES
D. E. Wilhelms *In its* Astrogeol. Studies. Part D: Studies for Space Flight Program May 1964 p 1–12 ref (See N66-3559621-30) CFSTI: HC $4.00/MF $1.00

The use of a single photograph is employed in a photometric technique for determining lunar slopes on the basis of darkening by shadows. A preliminary outline of the method, which was originally applied by van Diggelen in 1951 to low mare ridges, is presented which is usable for all types of terrain and will express results in terms of slope frequency distribution curves and maps of wide areas of lunar terrain. The procedure is outlined, and some sample curves are shown. It is noted that the method lends itself to automation techniques. M.W.R.

N66-35598*# Geological Survey, Washington, D. C.
A LUNAR ISOTONAL MAP
Robert J. Hackman *In its* Astrogeol. Studies. Part D: Studies for Space Flight Program May 1964 p 13–28 refs (See N66-3559621-30) CFSTI: HC $4.00/MF $1.00

An isotonal map was prepared by outlining areas of equal density on a photograph of the moon. TheLansberg region of the moon, in the center of the western half of the lunar disk, is illustrated; and densitometer curves are shown for the three transverses across this region. The curves demonstrate that the high-contrast film was exposed so as to enhance tone contrast in the darker parts of the photographs representing the maria. Tone differences in the brighter parts of the photograph, representing highlands and rays, are diminished. The dark tones are shifted from the shoulder of the gamma curve to the straight line portion, and exhibit more contrast; the brighter tones are shifted to the toe of the curve, and exhibit less contrast. The procedure followed is detailed, and it is concluded that such an isotonal map depicts small tone variations, designates brightest and darkest tone regions, and correlates tones with far greater precision than can be done by the eye. Ray material is considered to be more extensive than previously supposed, and tone variations on the lunar maria are said to be unrelated to recognizable topography. M.W.R.

N66-35600*# Geological Survey, Washington, D. C.
DENSITY OF SMALL CRATERS ON THE LUNAR SURFACE
H. J. Moore *In its* Astrogeol. Studies. Part D: Studies for Space Flight Program May 1964 p 34–51 refs (See N66-35596 21-30) CFSTI: HC $4.00/MF $1.00

Based on the influx of interplanetary debris, a high density of craters up to 10 meters in width is predicted for the lunar surface. It is speculated that 10% of the total lunar surface could be covered by well-preserved craters between 1 and 10 meters across, 10% by craters between 0.1 and 1 meter, and another 10% by craters between 0.01 and 0.1 meter. It is noted that extrapolated crater counts are probably invalid on the basis of significant differences between theoretical predictions and extrapolated values. Details are presented for the mass and number of bodies impacting the lunar surface, as well as the density of the secondary-impact craters which may contribute to the surface roughness of the moon. M.W.R.

N66-35605*# Geological Survey, Washington, D. C.
COMPUTER ANALYSIS OF AREAL MICROPHOTOMETER DATA FROM LUNAR PHOTOGRAPHS
A. T. Miesch and C. W. Davis *In its* Astrogeol. Studies. Part D: Studies for Space Flight Program May 1964 p 85–115 refs (See N66-35596 21-30) CFSTI: HC $4.00/MF $1.00

Techniques used for the analysis of microphotometric measurements taken on a full-moon photographic plate, as well as some preliminary computations are reported. The large areas of Procellarian mare material and Apenninian regional material were analyzed for variance of polynomial regression surfaces; and it is noted that more detailed microphotometric scanning is necessary for the examination of small areas such as Milichius and Milichius A. A highly generalized flow chart for the computer program being prepared for analysis of such data is shown, and some statistics that are provided by several parts of the program are tabulated. It is concluded that statistical analysis of such data results in information that can be interpreted in terms of known geologic features of the lunar surface; and that full automation will better utilize these techniques. Measures of overall albedo, variations in albedo, textural properties of albedo patterns, and regional degradation in albedo are provided; along with estimates of their statistical significance. M.W.R.

N66-35640# Defence Research Board, Ottawa (Ontario).
THE IRRELEVANCE OF BALDWIN'S RELATIONSHIP FOR DECIDING THE CAUSE OF LUNAR CRATER FORMATION
G. S. Shteinberg Jan. 1966 6 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 165, no. 1, 1965 p 55–57
(T-446-R; AD-631659) CFSTI: HC $1.00/MF $0.50

The meteoritic hypothesis of lunar crater formation is examined in light of Baldwin's relationships and volcanic calderas. Various theories on the volcanic (caldera) genesis for the lunar craters are reviewed. Other explosive volcanic formations morphologically similar to lunar craters and satisfying Baldwin's ratio are briefly mentioned. S.P.

N66-35662*# Geological Survey, Flagstaff, Ariz.
INVESTIGATION OF IN SITU PHYSICAL PROPERTIES OF SURFACE AND SUBSURFACE SITE MATERIALS BY ENGINEERING GEOPHYSICAL TECHNIQUES Annual Report
Joel S. Watkins, Robert A. Loney, and Richard H. Godson [1964] 90 p refs
(NASA Order T-2509)
(NASA-CR-65488) CFSTI: HC $2.50/MF $1.75 CSCL 08G

Purpose of the studies was to investigate feasibility of surface and subsurface property determination by geophysical Four study sites were selected in the Flagstaff area of Arizona; techniques and to prepare for lunar geophysical experiments. their geological characteristics are discussed, and maps and photographs of the areas are presented. Tests were conducted to determine the attenuation rate of seismic energy. The obtained energy spectra were analyzed. Seismic instruments and field methods used in the tests are described. Preliminary data suggest that (1) non-explosive energy sources can be detected to distances up to 500 feet on the lunar surface with instrumentation comparable to that presently available, and (2) frequencies observed at short distances are higher than originally expected. K.W.

N66-35767*# Alabama Univ., University. Bureau of Engineering Research.
A STUDY OF LUNAR RESOURCES: A PRELIMINARY REPORT OF SURFACE AND SOME OTHER MINING SYSTEMS Summary Report, 22 May 1965–1 May 1966
Reynold Q. Shotts, Robert M. Cox, David M. Grubbs, and H. William Ahrenholz 29 Apr. 1966 89 p refs
(Contract NAS8-20134)
(NASA-CR-77720) CFSTI: HC $3.00/MF $0.75 CSCL 22A

A study which advocates the use of extraterrestrial resources in lunar and planetary exploration projects, is reported. Discussed are: economic limits and time sequences for lunar resource utilization, lunar geology and the occurrence of water, the range of possible mining systems, models possibly suitable for surface mining, environmental problems of surface mining, and special problems in lunar mining. S.C.W.

N66-35925*# National Aeronautics and Space Administration. Manned Spacecraft Center, Houston, Tex.
STATUS REPORT: MANNED SPACECRAFT CENTER CHAMBERS "A" AND "B"
William K. Roberts *In* NASA. Lewis Res. Center High-Vacuum Technol., Testing, and Meas. Meeting Aug. 1966 p 151–164 (See N66-35906 21-11) CFSTI: HC $6.00/MF $1.50

Dimensions and operational characteristics of chambers being constructed for space environment simulation facilities are summarized. Chamber A, the space and lunar surface environment simulation chamber, is a stainless steel vessel 65 feet in diameter by 120 feet high with a side loading door 40 feet in diameter. When completely operational, this chamber will have solar simulation, which consists of a modular top sun and side sun system simulating the thermal flux of the sun (Johnson Curve). Chamber B, which is the space chamber for life systems and astronaut training, is relatively smaller than Chamber A. The top head can be removed for loading and unloading. Acceptance test results of chamber vacuum integrity, manlock vacuum integrity, and emergency repressurization are reported. Characteristics are also tabulated for a chamber being constructed as a bottom loading single-wall facility that will operate at 5×10^{-12} torr. S.P.

N66-35959*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Geo-Astrophysics Section.
POLARIMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES Third Interim Report
W. G. Egan and L. L. Smith Mar. 1966 75 p refs
(Contract NAS9-4942)
(NASA-CR-77764; RM-315) CFSTI: HC $2.50/MF $0.75 CSCL 03B

Progress is reported in blue (0.48μ), green (0.54μ), visual (0.54μ), and infrared (1.0μ) polarimetric measurements of simulated lunar surfaces. Emphasis is placed on previously derived polarimetric models which were modified by sprinkling with powders of volcanic ash, coral, furnace slag, and copper oxide. It was found that volcanic ash topped with particles of itself gives the closest match of the lunar surface. The major conclusion is that the polarization properties of the lunar surface can be produced by a suitable particulate coating of the underlying material. This will ultimately give information as to the choice of good landing areas for the Apollo mission. C.T.C.

N66-35966*# Geological Survey, Flagstaff, Ariz.
INVESTIGATION OF IN SITU PHYSICAL PROPERTIES OF SURFACE AND SUBSURFACE SITE MATERIALS BY ENGINEERING GEOPHYSICAL TECHNIQUES Annual Report, Fiscal Year 1965
Joel S. Watkins, Jean Cl. De Bremaecker, Robert A. Loney, James H. Whitcomb, and Richard H. Godson 1965 185 p refs
(NASA Order T-25091(G))
(NASA-CR-65489) CFSTI: HC $3.25/MF $1.25 CSCL 08G

CONTENTS:

N66-35967*# Geological Survey, Flagstaff, Ariz.
EXAMINATION OF THE LUNAR NEAR-SURFACE ROCKS BY ENGINEERING SEISMIC TECHNIQUES DURING EARLY APOLLO LANDINGS
Joel S. Watkins, Jean Cl. De Bremaecker (Rice Univ.), and Martin F. Kane *In its* Invest of in situ Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. 1965 13 p (See N66-35966 21-13) CFSTI: HC $3.25/MF $1.25

An experiment is proposed to measure the propagation velocity of compressional seismic energy, seismic energy attenuation, energy frequency, spectra, and the velocity of seismic shear waves in rock formations within 20 m of the lunar surface. The instrument system, which weighs less than 4.5 kg and operates on less than 20 watts of power, basically consists of 3 transistorized amplifiers, a 4-channel tape recorder, 3 miniature detectors, and a low-energy shooting device. Resultant data will be evaluated in terms of thickness of the fragmental layer of rocks on the lunar surface, degree of induration and bearing strength of the near-surface materials, and possibly the in situ elastic constants of the materials.

Velocity, amplitude, attenuation, and shooting efficiency data for this proposal were collected by an in situ seismic field crew at sites reconnoitered, mapped, and cored by an in situ geologic field crew. K.W.

N66-35972*# Geological Survey, Flagstaff, Ariz.
VELOCITIES AND ATTENUATIONS OF HEAD-WAVE AMPLITUDES OBSERVED IN LUNAR ANALOG ROCKS
Richard H. Godson, Joel S. Watkins, and Robert A. Loney *In its* Invest. of *In Situ* Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. 1965 26 p (See N66-35966 21-13) CFSTI: HC $3.25/MF $1.25

Seismic data collected at 11 sites, each having structural and lithologic similarities with those inferred for lunar near-surface materials, indicate that P head wave amplitude attenuation is strongly affected by fracturing. Velocity seems dependent on porosity and degree of cementation. The data have formed the basis for an estimate of amplitude attenuations on the lunar surface and were incorporated into the design of a proposed lunar engineering seismic experiment. Author

N66-36047*# Grumman Aircraft Engineering Corp., Bethpage, N. Y. Research Dept.
POLARIMETRIC MEASUREMENTS OF SIMULATED LUNAR SURFACES (PHASE II) Second Interim Report
W. G. Egan and L. L. Smith Feb. 1966 73 p refs
(Contract NAS9-4942)
(NASA-CR-77767; RM-312) CFSTI: HC $3.00/MF $0.75 CSCL 03B

The polarization properties of volcanic ash and furnace slag (simulated lunar surface) materials were investigated as a function of particle size, albedo, and porosity. The test specimens used, preparation of test samples, experiments performed, plane of polarization observations, results, and implications for lunar studies are discussed. Results indicate that the range of particle sizes on the lunar surface would have to exist either as a contiguous volume or as a simple, thin layer of the order of up to 1 mm thickness. This model is consistent with the Luna 9 observations, and also with thermophysical and photometric models. The observations were made under terrestrial conditions and the high vacuum conditions on the moon plus the effect of solar wind proton bombardment could possibly alter the results. It appears that the polarization-albedo-porosity relationship for particles below 0.5 mm in size may be used to advantage in elucidating the mechanical properties as well as the thermal properties of a lunar surface model. Curves of the polarimetric data obtained are given, along with photographs of the materials studied. L.S.

N66-36345*# Aeronutronic, Newport Beach, Calif.
RESEARCH, DEVELOPMENT, AND PRELIMINARY DESIGN FOR THE LUNAR PENETROMETER SYSTEM APPLICABLE TO THE APOLLO PROGRAM Final Report, Apr. 1965–Mar. 1966
27 Apr. 1966 642 p refs
(Contract NAS1-4923)
(NASA-CR-66178; U-3556) CFSTI: HC $6.91/MF $4.25 CSCL 22B

A lunar penetrometer for accurate measuring of lunar surface characteristics for the first Apollo landing is described. Results of more than 200 impact tests conducted with accelerometer-instrumented spherical projectiles are reported in investigations of soil penetration characteristics. Development of the omnidirectional telemetering penetrometer assembly is summarized, and data relay equipment and associated communication analyses are described. Testing of communication link systems is reported, as well as the reliability analyses and predictions. Major accomplishments include development of a workable omnidirectional accelerometer and impact-insensitive telemetry system, accumulation of impact signatures characteristic of a wide range of material properties, simulation of LEM lunar landings, and demonstration of a complete communications link from multiple penetrometers. S.P.

N66-36783*# Goodyear Aerospace Corp., Akron, Ohio.
COMPUTER STUDY TO DETERMINE THE EFFECT OF BALLOON FOOTPRINT AND OPTICAL CHARACTERISTICS ON MATERIAL TEMPERATURES OF A SPHERE ON THE LUNAR SURFACE FOR HIGH-NOON CONDITION
Jan. 1966 38 p refs
(Contract NAS1-5778)
(NASA-CR-66166; GER-12577) CFSTI: HC $2.00/MF $0.50 CSCL 22A

An analysis was made to determine the temperature distribution of a 12-foot balloon, with a diffuse surface, sitting on the lunar surface at high noon with two different footprints, 30° and 150°. The optical properties of the external surface were varied through several different values. Both the solar absorptance and total emittance have an appreciable effect on the temperatures. The smaller the footprint and smaller the range of the average temperature for the various emittances. The lunar properties of emittance and absorptance were varied through a range that would cover most published values for maximum lunar surface temperatures, 250° to 270°F. The effects on the balloon temperatures were minor. In general, the use of a rigidized sphere for a lunar landing aid appears very feasible since the footprint is not critical from a thermal standpoint, internal pressurization is not required, and a reflective sphere with a thin coating, which increases the emittance, results in very favorable temperatures for the Mylar. Author

N66-37366*# Geological Survey, Flagstaff, Ariz.
INVESTIGATION OF *IN SITU* PHYSICAL PROPERTIES OF SURFACE AND SUBSURFACE SITE MATERIALS BY ENGINEERING GEOPHYSICAL TECHNIQUES Annual Report, Fiscal Year 1966
Joel S. Watkins, ed. Jul. 1966 373 p refs
(NASA Order T-25091(G))
(NASA-CR-65502) CFSTI: HC $4.25/MF $2.00 CSCL 08G

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2. CORRELATION OF PHYSICAL PROPERTIES—FROM LABORATORY MEASUREMENTS AND FROM *IN SITU* MEASUREMENTS J. S. Watkins, C. H. Roach, and R. P. Christian p 25–35 refs (See N66-37368 22-13)
3. *IN SITU* DRILLING PROGRAM R. A. Elmer and L. A. Walters p 37–40 (See N66-37369 22-34)
4. LIMITS OF HEAD-WAVE AMPLITUDES FOR SHORT SPREADS FROM VARIOUS CHARGE SIZES, BLASTING CAPS, AND 45-KG WEIGHT DROP H. D. Ackermann p 41–49 ref (See N66-37370 22-13)
5. STRUCTURE AND COMPOSITION OF THE SOUTHERN COULEE, MONO CRATERS, CALIFORNIA—A PUMICEOUS RHYOLITE FLOW R. A. Loney p 51–92 refs (See N66-37371 22-13)
6. GEOLOGY AND PETROGRAPHY OF THE SONORA PASS SITE, MONO COUNTY, CALIFORNIA D. V. Haines p 93–113 refs (See N66-37372 22-13)
7. PETROGRAPHY AND GEOLOGY OF BISHOP TUFF AND MONO ASH SITES, CALIFORNIA D. V. Haines p 115–170 refs (See N66-37373 22-13)

8. PETROGRAPHY OF METEOR CRATER CORE 4, METEOR CRATER, ARIZONA D. V. Haines p 171–193 ref (See N66-37374 22-13)

N66-37367*# Geological Survey, Flagstaff, Ariz.
***IN SITU* PHYSICAL PROPERTIES MEASUREMENTS**
Lawrence A. Walters *In its* Invest. of *In Situ* Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. Jul. 1966 p 7–24 refs (See N66-37366 22-13) CFSTI: HC$4.25/MF$2.00

In situ bulk density, moisture content, bearing capacity, shear strength, and compressional wave velocity were determined simultaneously on seven lunar analog sites. Bearing capacities ranged from 3.4×10^4 to 45.9×10^6 dynes per cm ^{2} (0.5–675 psi). Density ranged from 0.43 to 1.87 g per cc. A large range of properties for the same material was found for various physical states of the material. Author

N66-37368*# Geological Survey, Flagstaff, Ariz.
CORRELATION OF PHYSICAL PROPERTIES—FROM LABORATORY MEASUREMENTS AND FROM *IN SITU* MEASUREMENTS
Joel S. Watkins, Carl H. Roach, and Ralph P. Christian *In its* Invest. of *In Situ* Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. Jul. 1966 p 25–35 refs (See N66-37366 22-13) CFSTI: HC $4.25/MF $2.00

Physical properties data have been measured in the laboratory from cores taken from the more than 600 m of NX diameter core collected at 10 lunar analog sites during the past 18 months. Core data from six sites have been examined in detail including preparation of 48 scatter diagrams in an attempt to find relationships between the measured physical properties. Correlations from the laboratory measurements have been poor at best and generally unrewarding. Correlation of 23 *in situ* measurements of bulk density and P-wave velocities are ɔncouraging. Author

N66-37373*# Geological Survey, Flagstaff, Ariz.
PETROGRAPHY AND GEOLOGY OF BISHOP TUFF AND MONO ASH SITES, CALIFORNIA
David V. Haines *In its* Invest. of *In Situ* Phys. Properties of Surface and Subsurface Site Mater. by Eng. Geophys. Tech. Jul. 1966 p 115–170 refs (See N66-37366 22-13) CFSTI: HC$4.25/MF$2.00

Two test sites, selected on the basis of geologic lunar analogies, indicate petrographic and physical characteristics pertient to lunar exploration and interpretation of lunar terrains. The Bishop Tuff site is located on a gently sloping, predominantly flat tableland broken by northerly-trending faults and underlain by Pleistocene Bishop Tuff in a youthful stage of erosion. Drilling indicates the prwsence of well-indurated tuff to 18.6 m, underlain by unconsolidated ash. The Mono Ash site is located on a gently sloping, predominantly flat surface underlain by pyroclastic debris derived from the adjacent Mono Craters. The surface soil is loose, dry lapilli ash of late Pleistocene to recent age, and is underlain by similar moist soil. Drill core shows the surface soil to be underlain by ash and consolidated pumice to a depth of 47 m. Occasional beds of clastic sand, up to 3.7 m thick, are interbedded with the pumice and ash and represent deposits formed in pulvial Lake Russell. Tuff (probably equivalent to the previously mentioned Bishop Tuff) occurs below a depth of 47 m. Strongly eutaxitic texture, spherulitic structure developed in pumice inclusions, and flattened lenses containing obsidian indicate higher temperature and pressure conditions during deposition than occurred at the Bishop Tuff site. Petrographic features can be correlated with higher bulk density and lower porosity of the tuff at the Mono Ash site. Author

N66-37544*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
RADAR STUDIES OF THE MOON Quarterly Progress Report No. 3, 1 May–31 Jul. 1966 19 Sep. 1966 42 p refs
(Contract NSR-22-009-106)
(NASA-CR-78370) CFSTI: HC $2.00/MF $0.50 CSCL 03B

Section I is concerned with the observational results of an exhaustive study of the mean depolarizing properties of the lunar surface at 23 cm. It also contains the results of a determination of the angular scattering law of the moon at 3.8 cm, as well as the results of measuring the dependence of the scattering characteristics of the surface on the linear polarization of the scattering at that wavelength. Section II relates in part to the progress of the mapping program at 3.8 cm and in part to the radar observations at 8 mm. Section III discusses a method of observing the lunar surface whereby the ambiguity inherent in the range-Doppler mappingtechnique can be removed without relying on the resolution of the antenna beam. Author

N66-37853# Academy of Sciences (USSR), Leningrad.
BULLETIN OF THE INSTITUTE FOR THEORETICAL ASTRONOMY, VOLUME X, NUMBER 3 (116) [BYULLETEN' INSTITUTA TEORETICHESKOI ASTRONOMII, TOM X, NO. 3 (116)]
G. A. Chebomarev, ed. 1965 76 p refs In RUSSIAN
CFSTI: HC $3.00/MF $0.75

CONTENTS:

N66-37858# Academy of Sciences (USSR), Leningrad.
ON THE DETERMINATION OF THE CONSTANTS OF PHYSICAL LUNAR LIBRATION
M. D. Polanouere *In its* Bull. of the Inst. for Theoret. Astronomy, Vol. 10, No. 3 (116) 1965 p 230–235 refs In RUSSIAN; FRENCH summary (See N66-37853 23-30) CFSTI: HC $3.00/MF $0.75

Observations of the position of the crater "Mosting A" in relation to the visible contours of the moon are used to show the direct relation of the visual angles and the parameters derived from the constants of the lunar physical libration. Equations and matrix operations for determining the interdependence between observed and unknown quantities are given. Transl. by K.W.

N66-38413*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
FIXED-BASE VISUAL-SIMULATION STUDY OF MANUALLY CONTROLLED TRANSLATION AND HOVER MANEUVERS OVER THE LUNAR SURFACE
G. Kimball Miller, Jr. Washington, NASA, Oct. 1966 26 p refs
(NASA-TN-D-3653) CFSTI: HC $1.00/MF $0.50 CSCL 05H

A fixed-base visual-simulation study has been conducted to determine the ability of the human pilot to control a lunar landing vehicle manually during translation and to hover above various landing sites in a given landing area. The general landing area used in this investigation was the interior of the crater Alphonsus as created by the lunar orbit and landing approach. The investigation employed a closed-circuit television system for image generation and permitted all six rigid-body degrees of freedom of the vehicle. The pilot controlled the vehicle through a fixed main-engine thruster in conjunction with a rate-command landing-approach transition phase of a typical lunar landing trajectory. The pilot was required to switch to manual control in order to place the landing vehicle in near-hover conditions over any one of a number of sites that he felt would be acceptable for landing. The results of the investigation showed that the pilots, using only a three-axis gyro-horizon nulled to the local vertical and an out-the-window view of the lunar surface, could consistently establish near-hover conditions over a fairly large lunar area. The landing sites attained by the pilots extended from approximately 2300 feet (701-0) up range of (before) to approximately 7700 feet (2347.0 m) down range of (beyond) the nominal landing site. Author

N66-38493*# Bendix Corp., Ann Arbor, Mich. Systems Div.
LUNAR SIMULATION MODEL AND OPTICAL STUDIES FOR LUNAR ORBITER SYSTEM SUPPORT
H. Graboske and E. Marsh Sep. 1966 63 p refs
(Contract NAS1-5710)
(NASA-CR-66176; BSR-1362) CFSTI: HC $2.50/MF $0.75 CSCL 14B

The construction, calibration, and analysis of a model which simulates the topographic and photometric characteristics of the lunar surface are described. A quantitative evaluation of the photometric and photogrammetric methods for remotely measuring the topographic features of the lunar surface is made based upon experimental data obtained from the model. Minimum accuracies for photogrammetric measurements, photometric slope, and albedo determinations are discussed for several experimental sensor-sun-surface geometries. Author

N66-38578# Boeing Scientific Research Labs., Seattle, Wash. Geo-Astrophysics Lab.
INFRARED AND VISIBLE IMAGES OF THE ECLIPSED MOON OF DECEMBER 19, 1964 Final Scientific Report, 25 Sep. 1964–31 Dec. 1965
John M. Saari, Richard W. Shorthill, and Thomas K. Deaton Jul. 1966 48 p refs
(Contract AF 19(628)-4371)
(D1-82-0533; AFCRL-65-886; AD-636295) CFSTI: HC $2.00/MF $0.50

The moon was scanned with 10 second arc resolution at 0.45 and 10–12 microns during the total lunar eclipse of December 19, 1964. It was found that the lunar surface exhibits a surprising amount of thermal inhomogeneity. Hundreds of thermal anomalies were observed, most of which can be identified with bright craters or white areas. Certain maria and portions of maria were found to be thermally enhanced over their environs during the eclipse. The analog signals recorded on magnetic tape were used to make visible and infrared images from the scan data. Author

N66-38712*# Arizona Univ., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, VOLUME 5, PART 1, NUMBER 70
D. W. G. Arthur, Ruth H. Pellicori, and C. A. Wood 25 May 1966 216 p
(Grant NsG-161)
(NASA-CR-78466) CFSTI: HC $4.00/MF $1.25 CSCL 03B

Lunar craters on the visible hemisphere recognizable with reasonable certainty on photographs, and having diameters greater than 3.5 km in the fourth lunar quadrant are catalogued; details include designation, diameter, position, central peak information, and state of completeness for each. New names, approved by the International Astronomical Union, are given to large or conspicuous craters in the limb regions wherever such additions are considered necessary. The catalog contains about 8,000 items and is illustrated by 11 schematic maps. An alphabetic index, and map locations of named craters are included. R.Ll.

N66-38803*# Texaco Experiment, Inc., Richmond, Va.
AN EXPERIMENTAL STUDY OF FLUIDIZATION PROCESSES UNDER LUNAR CONDITIONS
Gordon H. Miller and Irving R. King Washington, NASA, Oct. 1966 102 p refs
(Contract NAS5-9231)
(NASA-CR-627) CFSTI: HC $2.50/MF $0.75 CSCL 03B

Factors of fluidization are examined to select those materials suitable for simulating lunar soils in a fluidization experiment and to deduce the effect that the lunar hard vacuum will have on the fluidization process. Talc, spent fluidized catalyst, high-porosity fluidized catalyst, granite dust, ash-flow tuff, and glass microspheres were examined to determine the effect of size, size distribution, and shape on settling rate after fluidization vapor is cut off; the maximum size which will permit satisfactory horizontal flow; and such physical data as voids fraction, surface area, density and bulk density of the materials. An examination was also made of the effect of vacuum on fluidization in the pressure region below about 4 torr where the mean free path of the gas is of the order of the particle size. It was established that low pressure, in the range where the mean free path of the vapor becomes larger than the particle dimensions, has a pronounced effect on fluidization. S.P.

N66-39434# Library of Congress, Washington, D. C. Aerospace Technology Div.
LUNAR DIMENSIONS—ANNOTATED BIBLIOGRAPHY Surveys of Foreign Scientific and Technical Literature
Joseph Javis and Daniel W. Michaels 5 Aug. 1966 26 p refs
(ATD-B-66-96)

This annotated bibliography was compiled from Soviet open sources published 1964–1966 and one Chicom open source published in 1965. It is the second in a series and it reflects Soviet developments from about mid-1965 in investigating lunar revolution, rotation, libration, and mapping techniques. Pertinent information included: velocity profile of the Moon, libration effect based on meridian observations of lunar diameters in Greenwich in 1900–1954, determination of the equinox correction from lunar observations by Newcomb's method, methods for computing the ephemerides of the Moon, lunar polygonometry technique, determination of the constants of lunar libration, theory of physical libration of the Moon, diurnal rotation of planets, gravity and shape of the Moon, lunar measuring equipment. Author

N66-39543*# Trident Engineering Associates, Inc., Annapolis, Md.
PROJECT MOON-BLINK Final Report
Washington, NASA, Oct. 1966 79 p refs
(Contract NAS5-9613)
(NASA-CR-630) CFSTI: HC $2.50/MF $0.75 CSCL 03A

Work performed consisted of 1) the development of devices to improve observation of unusual color occurrences on the moon in order to record and identify such phenomena and 2) a lunar surveillance program via telescope employing this especially designed equipment. Trident personnel developed and fabricated a rotating-filter, image-intensification instrument called a "Moon-Blink" device. Using this device they maintained a constant

surveillance and observed several color phenomena. The following conclusions were made: (1) Red colorations do appear on the lunar surface. (2) these colorations may persist for several hours. The Trident sighting, on November 15, 1965, lasted at least four hours. Author

N66-39924*# Douglas Aircraft Co., Inc., Newport Beach, Calif. Astropower Lab.
RESEARCH ON THE UTILIZATION OF PATTERN RECOGNITION TECHNIQUES TO IDENTIFY AND CLASSIFY OBJECTS IN VIDEO DATA Technical Progress Report No. 2, 1 Oct. 1965–20 May 1966
Jun. 1966 56 p refs
(Contract NAS12-30)
(NASA-CR-79109; SM-48464-TPR-2) CFSTI: HC $3.00/MF $0.75 CSCL 14E

Experimental results obtained on features of the lunar terrain are summarized as follows: (1) The quadratic property filters (DAID units) provided significantly higher performance levels than the linear property filters (SDA units), although the total number of adjustable parameters in the specification of the units was about the same for both property filter sets. (2) When the generalization performance was low, Bayes weights and forced learning gave the best results with the DAID units. At intermediate performance levels, all of the techniques were approximately equal. At performance levels high enough for an operational system, iterative design was the top performer. (3) The poor performance of the MADALINE appears to be due to the inefficiency of the algorithm coupled with the limitation on the design time. (4) The performance obtained appears to be very strongly related to the size of the significant pattern features relative to the size of the sensory field. When the significant feature represents less than 1% of the field, the best generalization performance achieved was 64%. When the feature was 5 to 10% of the field, the best generalization was 76%. With features covering 30% of the field, the generalization performance better than 99% was achieved. Author

N66-39950*# National Aeronautics and Space Administration, Washington, D. C.
SECOND ORBITER LAUNCH SCHEDULED IN NOV. 6–11 PERIOD
30 Oct. 1966 61 p
(NASA-News Release-68-286) Available from the Scientific and Technical Information Division CSCL 22B

Descriptions are presented of the Lunar Orbiter B spacecraft; its camera, photo taking process, photo processing, photo readout, electric power, attitude and velocity control, communications, and the temperature control systems; its tasks of photography, landing site locations, selenodesy, and meteoroid and radiation measurements; the Atlas-Agena D launch vehicle and vehicle statistics; the Deep Space Network including data acquisition and evaluation; the Atlas-Agena/Lunar Orbiter mission and countdown events; and major flight events. R.N.A.

N66-39959*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
A STUDY OF THE DEPOLARIZATION OF LUNAR RADAR ECHOES
Tor Hagfors [1966] 49 p refs
(Contract NSR-22-009-106)
(NASA-CR-79098) CFSTI: HC $2.00/MF $0.50 CSCL 03B

The radar backscattering characteristics of the lunar surface are examined in detail at a wavelength of 23 cm. The backscattered waves are studied both for circular and for linear polarization of the transmitted wave. Effects relating to the orientation of the local plane of incidence on the moon with respect to the polarization of transmitted or scattered waves are investigated. The experimental results appear to support strongly the hypothesis that the returns at oblique angles of incidence arise through single scattering from discrete objects as opposed to the returns at near normal incidence which are dominated by quasispecular reflection. Author

N66-39994*# Consultants and Designers, Inc., Arlington, Va.
ON THE INAPPLICABILITY OF THE BALDWIN CORRELATION FOR THE DETERMINATION OF THE CAUSES OF EMERGENCE OF LUNAR CRATERS [O NEPRIMENIMOSTI SOOTNOSHENIYA BOLDUNA DLYA OPREDELENIYA PRICHIN VOZNIKNOVENIYA LUNNYKH KRATEROV]
G. S. Shteinberg 22 Dec. 1965 6 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR, Astron. (Moscow), v. 165, no. 1, 1965 p 55–57
(Contract NAS5-3760)
(NASA-CR-79089; ST-LPS-10431) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Comparing the results of research by other authors with some observations of volcanic craters after aerial photographs taken in eastern volcanic belt, the present author points to the necessity of detailed morphological analysis of the latest data on lunar objects, comparing them with meteoritic and volcanic forms, since any alternate approach to causes having conditioned the formation of lunar relief does not allow a satisfactory explanation of all the facts observed. The author states that the "single-eventness" in the formation of meteoritic forms, and the duration and phase multiplicity of volcanic activity, must unconditionally, find reflection in the morphology of craters. Author

1967
STAR ENTRIES

N67-10061*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SURVEYOR I MISSION REPORT. PART II: SCIENTIFIC DATA AND RESULTS
10 Sep. 1966 112 p refs
(Contract NAS7-100)
(NASA-CR-79150; JPL-TR-32-1023) CFSTI: HC $4.00/MF $0.75 CSCL 22A

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N67-10062*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
SUMMARY
L. D. Jaffe and E. M. Shoemaker *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 1-2 (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

A summary of the scientific accomplishments of Surveyor I on the lunar surface is given, including photography, temperature measurements, surface observations, and radar cross section. K.W.

N67-10063*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
INTRODUCTION
L. D. Jaffe and S. E. Dwornik *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 3-6 ref (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

Mission objectives, equipment, configuration, trajectory, landing site, and landing operation are briefly summarized. Details are given of the TV camera, picture transmission, and camera operations. K.W.

N67-10064*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SURFACE TOPOGRAPHY
J. J. Rennilson, J. L. Dragg, E. C. Morris, E. M. Shoemaker, and A. Turkevich *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 7-44 refs (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

Characteristics, capabilities, and operations of the Surveyor I camera system are initially discussed, followed by an evaluation of the photographs and data that were obtained. Covered are: (1) landscape features on horizon; (2) general slope of landing site; (3) morphology and structure of terrain around spacecraft; (4) size distribution of small craters; (5) distribution of blocks and coarse debris; (6) size distribution of debris on lunar surface and characteristics of fine matrix; (7) cohesion and thickness of surficial fragmental layer; (8) material ejected by impact of spacecraft footpad; and (9) photometry and colorimetry. Graphs, tables, and selected photographs are included. K.W.

N67-10065*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SURFACE THERMAL CHARACTERISTICS
J. W. Lucas, J. E. Conel, R. R. Garipay, W. A. Hagemeyer, and J. M. Saari *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 45-59 refs (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

Although the spacecraft carried no instruments, as such, to measure thermal characteristics, the temperatures of the outer surfaces of two electronic compartments were highly dependent on the local thermal radiation environment and largely independent of internal spacecraft temperatures. These spacecraft temperatures were used to estimate the average brightness temperature of those portions of the surface viewed by each compartment. A summary is given of pertinent terrestrial infrared and photometric observations of the Surveyor I site. The procedures used to arrive at surface temperatures are described in detail. A comparison is presented of Surveyor I data and theory. The article concludes with a discussion of dust coverage of the spacecraft from a thermal standpoint. K.W.

N67-10066*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SURFACE ELECTRICAL PROPERTIES
W. E. Brown *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 61-67 (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

Two radar systems were used on the spacecraft; they were the altitude marking radar, and the radar altimeter and Doppler velocity sensor radar. Parameters and performance of the two systems are discussed. It is concluded that (1) radar cross section values are approximately as expected from earth-based measurements; (2) echo was returned by the visible surface or within 30 cm to 60 cm of the surface; (3) plumes of the vernier engines had no measurable effect upon the radar signal strength; and (4) one of the off-normal beams traversed a crater-like surface anomaly approximately 1 km wide and 2 km southwest of the touchdown point. K.W.

N67-10067*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SURFACE MECHANICAL PROPERTIES
E. M. Christensen, S. A. Batterson, H. E. Benson, C. E. Chandler, R. H. Jones et al *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 69-85 refs (See N67-10061 01-30) CFSTI: HC $4.00/MF $0.75

This interpretation of the lunar surface properties is based on (1) pictures that show the lunar surface area disturbed by the footpads and the crushable blocks, and (2) histories of axial loads in the shock absorbers on each of the three legs during the landing. A detailed description is given of the landing gear and the sequence of descent and touchdown. Final descent velocities and attitudes were determined by studying and correlating the velocity data from the radar altimeter and Doppler velocity sensor, the three gyro angular rates about the spacecraft axis, and the precise timing of the final descent and touchdown events. The analytical simulations of the landing dynamics, based upon extensive computer simulation studies, are also briefly discussed. K.W.

N67-10069*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
APPENDIX A: OBSERVATIONS OF DUST PARTICLES
W. A. Hagemeyer *In its* Surveyor I Mission Rept., Part II 10 Sep. 1966 p 93-97 ref (See N66-10061 01-30) CFSTI: HC $4.00/MF $0.75

Compared are TV pictures, taken on two different days, showing the location of dust particles on the radiators of the thermal compartments. Some changes in the apparent dust location are pointed out. A laboratory simulation was made subsequent to the flight, and the results are briefly discussed. K.W.

N67-10190*# National Aeronautics and Space Administration, Washington, D. C.
THE VALUE OF GEOGRAPHIC-GEOLOGIC METHODS OF STUDYING THE MOON [ZNACHENIYE GEOGRAFO-GEOLOGICHESKIKH METODOV IZUCHENIYA LUNY]
Yu. A. Khodak, V. V. Kozlou, I. N. Tomson, and L. V. Khoroshilov Feb. 1964 9 p refs Transl. into ENGLISH from Kosmich. Issled. (Moscow), v. 1, no. 3, Dec. 1963 p 460-464
(NASA-TT-F-8834) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Geographic and geologic methods of studying the moon, especially those based on structural geomorphology and structural and historical geology, are discussed. It is suggested that lunar research would benefit from the integration of geographic-geologic (as compared with terrestrial material) and astronomical methods of study. Geographic-geologic investigations already carried out are reviewed, together with the meteoritic theory of the development of lunar surface and structure. R.Ll.

N67-10731# California Univ., La Jolla.
ORIGIN OF THE MOON
Harold C. Urey Jun. 1966 20 p refs Presented at the Mantles of the Earth and Terrestrial Planets, Newcastle-upon-Tyre, England, 30 Mar.-7 Apr. 1966
(Contract AT(11-1)-34)
(UCSD-34P43-5; CONF-660331-1) CFSTI: HC $1.00/MF $0.50

A review is presented of various hypotheses on the origin of the moon. NSA

N67-10864*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
OPTICAL ASTRONOMY PACKAGE FEASIBILITY STUDY FOR APOLLO APPLICATIONS PROGRAM Executive Summary Report
E. H. Wells 5 Aug. 1966 19 p
(NASA-TM-X-53496) CFSTI: HC $1.00/MF $0.50 CSCL 22B

The feasibility of adapting the Goddard Experiment Package, developed for the Orbiting Astronomical Observatory, to Apollo missions on the lunar surface is investigated. Full consideration is given to an entire mission utilizing typical astronomical experiments. Data is provided to assist in program planning of lunar surface optical astronomy missions and equipment. Evolutionary growth potentials were considered and all indications were that a 5- to 6-year period is realistic for the time required from initiation of the project to flight. Author

N67-11009# Boeing Scientific Research Labs., Seattle, Wash.
TRANSIENT RADIATIVE HEAT EXCHANGE AT THE SURFACE OF THE MOON
D. F. Winter Aug. 1966 26 p refs
(D-82-0559; AD-639051) CFSTI: HC $2.00/MF $0.50

The surface of the Moon is characterized as an evacuated particulate medium in which radiative heat exchange between solid surfaces plays a decisive role in determining the transient behavior of the apparent temperature. A simple model is developed which permits quantitative comparisons with lunar surface temperature variations, observed in the 8-12 micron band, both during a lunation and a lunar eclipse. Thermal properties and certain surface characteristics are thereby inferred, including an effective microstructure scale of the order of 0.1 mm Author (TAB)

N67-11734*# Volt Technical Corp., Washington, D. C.
LUNA-12 TRANSMITS PHOTOGRAPHS ["LUNA-12" PEREDAYET SNIMKI]
3 Nov. 1966 6 p Transl. into ENGLISH from Pravda (Moscow), 30 Oct. 1966 6 p
(Contract NAS5-12487)
(NASA-CR-79544; ST-PR-LPS-10534) CFSTI: HC $1.00/MF $0.50 CSCL 22B

Two photographs of the lunar surface taken by LUNA XII are discussed. The photographs were taken from an altitude of 100 km above the Moon and represent an area of the Mare Imbrium. Also mentioned is the lunar orbit of the probe. K.W.

N67-11951*# Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
STUDY OF LUNAR, PLANETARY, AND SOLAR TOPOGRAPHY First Phase Report, 1 Jul. 1965–15 Apr. 1966
C. E. Campbell Washington, NASA, Nov. 1966 130 p refs
(Contract NAS12-19; Proj. Tech Top)
(NASA-CR-650) CFSTI: HC $3.75/MF $1.00 CSCL 03A

This report presents the results of the first phase of a program to assess the state of the art in topographic information collection systems for application to the space program. The method of acquisition that may apply for lunar, planetary and solar surfaces are described. A detailed investigation of the stereo imagery method is reported including requirements, sensors and errors involved. The applicability of holographic methods is evaluated with the most promising application concluded to be in the area of image enhancement. The transmission and display of three-dimensional information are examined in terms of requirements and methods. Other subjects surveyed include the peculiar problems of changing solar topography, measurements to test the general theory of relativity and measurement of stellar parallax from a space vehicle. Conclusions and recommendations for improving the state of the art, where possible, are given. Numerous references are included. Author

N67-12005# Joint Publications Research Service, Washington, D. C.
STRATIFIED AND MULTI-FACETED FORMS ON LUNAR PANORAMAS OBTAINED BY "LUNA-9"
V. M. Vakhnin and G. I. Zmiyevskaya 25 Nov. Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 170, no. 3, 1966 p 560
(JPRS-38792; TT-66-35216) CFSTI: $1.00

Graphic interpretations of lunar surface faceted and stratified structures which were detected on panoramas obtained by the Luna-9 artificial satellite are cited. S.C.W.

N67-12006# Joint Publications Research Service, Washington, D. C.
STUDIES OF THE INTENSITY AND SPECTRAL COMPOSITION OF LUNAR GAMMA RADIATION BY THE AUTOMATIC STATION "LUNA-10"
A. P. Vinogradov, Yu. A. Surkov, and G. M. Chernov 25 Nov. 1966 8 p refs Transl. into ENGLISH from Dokl. Akad. Nauk SSSR (Moscow), v. 170, no. 3, 1966 p 561–564
(JPRS-38793; TT-66-35217) CFSTI: HC $1.00

Gamma spectra of lunar surface rocks which were obtained by the Luna-10 artificial satellite were analyzed to determine the intensity and spectral composition of lunar gamma radiation. Using a scintillation gamma spectrometer, an attempt was made to estimate the relative content of potassium, thorium, and uranium in rocks of the lunar surface. Gamma radiation was recorded in the range of energies from 0.3 to 3.1 MeV and from 0.15 to 1.5 MeV. Measurements covered relatively broad areas of the surface including regions of the continents and seas of both visible and far sides of the moon. Lunar gamma spectra were found to differ greatly from the spectra of terrestrial gamma radiation. Lunar gamma radiation consisted of radiation arising at the time of interaction of cosmic rays with lunar matter and during the decay of cosmogenic radioisotopes. The total intensity of gamma radiation on the lunar surface exceeded that of the earth's crust by 1.5^{-2} with little regional variation. In the total intensity of gamma radiation of lunar rocks about 90% was caused by cosmic rays and not more than 10% was caused by the decay of potassium, thorium, and uranium. These data negated the theory that lunar surface rocks in the areas studied were similar in composition to terrestrial granites. S.C.W.

N67-12165*# Allis-Chalmers Mfg. Co., Milwaukee, Wis. Space and Defense Sciences Dept.
LUNAR SURFACE ROUGHNESS COMMINUTION STUDY Final Report, 20 Jul. 1964–7 Apr. 1965
T. P. Meloy and L. H. Faust Apr. 1965 90 p refs Prepared for JPL
(Contracts NAS7-100; JPL-950919)
(NASA-CR-80137) CFSTI: HC $3.00/MF $0.75 CSCL 03B

The roughness of the lunar surface is estimated by considering the process of cratering caused by the infall of meteoric bodies. Size distribution and depth of the resulting dust or rubble layer has been calculated. Individual crater formation is analyzed, and the size distribution of the ejected material from individual craters is computed. The distance that the material is thrown is also computed. Using a matrix method, an estimate is made of the size distribution and depth of the dust on the moon as a function of time. It is concluded that near the edge of a new, large crater a number of large debris blocks can be expected and hazardous landing conditions would exist in this region. A.G.O.

N67-12180*# Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies.
ANALYSIS OF LUNAR SURFACES Final Report, Feb. 1961–Jul. 1965

Anthony Turkevich May 1966 16 p refs
(Grant NsG-127-61)
(NASA-CR-75121; EFINS-66-49; EFINS-66-47) CFSTI: HC $1.00/MF $0.50 CSCL 03B

A method for chemical analysis of lunar and planetary material by use of alpha particles was investigated, and analytical procedures for an alpha-scattering experiment on a suitable lunar vehicle were developed. The method makes use of the interactions of a collimated beam of energetic, heavy, charged particles, with matter, to determine the chemical composition of the sample being analyzed. Fundamental studies on this method have been carried out in parallel with the development of instruments designed to meet the requirements of specific space missions. In discussing the results of these studies condideration is given to the scattering of alpha particles, the protons produced by alpha particles, the role of ionization energy loss by charged particles in interpreting the spectra of scattered alpha particles and protons, and an interpretation of complex spectra in terms of chemical composition. Future prospects of the technique are also mentioned with particular emphasis slanted toward use on the Surveyor Lunar Mission.
A.G.O.

N67-12202*# Consultants and Designers, Inc., Arlington, Va.
SCIENTIFIC RESULTS OF PROCESSING OF PANORAMAS OBTAINED FROM PHOTOGRAPHS OF THE LUNAR SURFACE TAKEN FROM "LUNA-9"
A. L. Lebedinskiy 13 Jun. 1966 13 p Transl. into ENGLISH From Reprint of the USSR Acad. of Sci., 1966
(Contract NAS5-9299)
(NASA-CR-80180; ST-LPS-10493, rev. 1) CFSTI: HC $1.00/MF $0.50 CSCL 22A

Scientific processing of three panoramas transmitted from the lunar surface by a Soviet television camera at respective heights of 7, 14, and 27° of the sun above the lunar horizon, revealed that the landing station was located on the slope of a depression. Morphological comparison of the different panoramas led to the conclusion that tiny details of the lunar surface structure are: (1) lunes or craterlets of small dimensions with hardly noticeable rims; (2) linear structures usually intersecting one another in various directions; and (3) stones. The predominating type of relief in the portion studied constituted circular pits, craters, funnels, and craterlets having a minimum dimension of about 5 cm. Judging from shadows, the steepness of the inner slopes of craterlets with dimensions of more than one decimeter may exceed 41°. On a whole, the picture observed near the lunar station corresponded to a gradual disappearance of a superficial layer's matter. G.G.

N67-12235*# Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.
COMPUTATION OF DEBRIS PROBLEM CAUSED BY ACTIVE SEISMIC SHOTS ON THE LUNAR SURFACE
Charles Broder May 1966 60 p refs
(Contract NAS8-20166)
(NASA-CR-78970; R-197) CFSTI: HC $3.00/MF $0.75 CSCL 03B

Impact densities and velocity distribution of the debris resulting from explosions on the lunar surface were determined. Consideration is given to the type of soil that will give the best empirical data. Crater volumes and shapes are predicted, and the ejecta patterns determined are based on radial ejection of material from the charge center. Author

N67-12239*# Consultants and Designers, Inc., Arlington, Va.
SCIENTIFIC RESULTS OF PROCESSING OF PANORAMAS OBTAINED FROM PHOTOGRAPHS OF THE LUNAR SURFACE TAKEN FROM "LUNA-9"
A. I. Lebedinskiy 26 May 1966 13 p Transl. into ENGLISH from reprint of the USSR Acad. of Sci., 1966
(Contract NAS5-9299)
(NASA-CR-80171; ST-LPS-10493) CFSTI: HC $1.00/MF $0.50 CSCL 22A

Results from the preliminary processing of "LUNA-9" moon surface photographs are presented. Three panoramas are shown with the sun at 7°, 14°, and 27° above the lunar horizon. Based on the consideration of images and morphological comparisons of monotypic details in various regions of the panorama, characteristic types of microsculptures are outlined and tiny details of the lunar surface structure are described. A.G.O.

N67-12268*# Bureau of Mines, Minneapolis, Minn. Twin Cities Mining Research Center.
MULTIDISCIPLINARY RESEARCH LEADING TO UTILIZATION OF EXTRATERRESTRIAL RESOURCES
Quarterly Status Report, 1 Jul.–1 Oct. 1966
1 Oct. 1966 32 p refs
(NASA Order R-09-040-001)
(NASA-CR-80121) CFSTI: HC $2.00/MF $0.50 CSCL 08G

Physical work in multidisciplinary research on extraterrestrial resources centered on the following topics: background information analysis on rocks that simulate the range of materials most likely to be found on a lunar surface; sample collection and physical properties of simulated lunar materials; gas adsorption and outgassing of one-inch cube of semiwelded tuff in a vacuum system; static and dynamic properties of simulated lunar materials and rocks; classification of ground silica into six selected particle size bands; development of bombproof laboratory facility for electronic and optical instrumentation; literature search on volcanism and ore genesis as related to lunar mining; determination of reduction rate of silica with carbon; equipment development for vacuum contact electrification of minerals; pressure tests on sulfuric acid; and other related subjects. G.G.

N67-12731# Academy of Sciences (USSR), Leningrad. Pulkovo Observatory.
PHYSICAL OBSERVATIONS OF THE LUNAR SURFACE
N. A. Kozyrev *In* NAS-NRC Extraterrest. Life 1966 p 102–123 refs Reprinted (See N67-12721 03-04) Available from NAS-NRC, Washington, D. C.: $6.00

Observations by Dinsmore Alter of the lunar haze which temporarily obscures details of the lunar craters are discussed, as are spectral observations of Alphonsus made on November 3, 1958. Spectrograms of the latter are included; and on one it is noted that the ordinary spectrum of the central peak has been covered by an additional emission whose most distinctive feature is a group of bands with a comparatively sharp red edge at about 4740A. This is typical of the spectra of cometary heads, and is basically a band in the Swan resonance series of the diatomic molecules of carbon. Spectral observations of Alphonsus on October 23, 1959, indicate that an active volcanic process at least equal to the large terrestrial eruptions took place. The axial ridge of the Alphonsus crater is considered to be in the stage of formation. It is conjectured that the central peaks of lunar craters have the same origin as terrestrial ones; and the craters themselves bear a similarity to the calderas of terrestrial volcanoes. The fact that the lunar craters are larger than terrestrial ones is related to the small gravity of the moon as compared to that of earth. M.W.R.

N67-12746# Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies.
AGE OF CRATERS ON MARS

Edward Anders and James R. Arnold (Calif. Univ., San Diego) *In* NAS-NRC Extraterrest. Life 1966 p Reprinted (See N67-12721 03-04) Available from NAS-NRC, Washington, D. C.: $6.00 (Grants NsG-366; NsG-321; Contract AT(11-1)-382)

Rate of crater formation on Mars is calculated to be about 25 times higher than that on the moon. The crater density observed by Mariner IV points to an age only one-sixth that of the lunar maria, or 300 to 800 million years. Hence, no conclusions can presently be drawn from these photographs concerning the early Martian environment. Author

N67-12747# Oliver Machinery Co., Grand Rapids, Mich.
MARS: AN ESTIMATE OF THE AGE OF ITS SURFACE
Ralph B. Baldwin *In* NAS-NRC Extraterrest. Life 1966 p 318–321 refs Reprinted Revised (See N67-12721 03-04) Available from NAS-NRC, Washington, D. C.: $6.00

The age of the Martian surface as seen by Mariner IV is calculated to be between 340 and 680 million years on the basis of comparisons of Martian and lunar craters. In the small area of Mars photographed, crater size varies from 3 to 120 km in diameter. It appears highly probable that the surface of Mars photographed by Mariner IV is quite young from a geological point of view. If the present influx of large infalls on Mars is as low as the observed micrometeorite flux near the planet, the age of the Martian surface is estimated to be 6.8×10^8 years. M.W.R.

N67-12864# Los Alamos Scientific Lab., N. Mex.
CONTRIBUTIONS TO THE FEASIBILITY STUDY OF AN EARLY LUNAR FLARE
R. A. Jeffries and Jerry Wackerle 25 Jul. 1966 81 p refs (Contract W-7405-ENG-36)
(LA-3453) CFSTI: HC$3.00/MF$0.75

A limited investigation of certain aspects of the feasibility of the ELF concept, a proposal for obtaining chemical and physical information about the lunar surface, is described. This information will be gathered by the earth-based observation of the impact of a highly reactive chemical flare upon the moon. Results are given of shock-wave compression measurements of the liquid chlorine trifluoride–aluminum mixture currently favored as the flare material. Also reported are experiments which demonstrated that modest amounts of this mixture do not sustain high-order detonation under strong shock loading. Finally, experiments are described which were designed to simulate, in reduced scale, the anticipated impact event. While some observations of the latter experiments did, on cursory study, appear detrimental to the feasibility of the ELF proposal, on more careful examination these results were invariably caused by experimental limitations and were not due to any inherent weaknesses in the concept. Suggestions are made for future investigations leading to a more thorough understanding of an impact event. Author (NSA)

N67-12908*# Volt Technical Corp., Washington, D. C.
MEASUREMENTS OF GAMMA RADIATION OF THE LUNAR SURFACE ON THE SPACE STATION, LUNA-10 [IZMERENIYA GAMMA-IZLUCHENIYA LUNNOY POVERKHNOSTI NA KOSMICHESKOY STANTSII LUNA-10]
A. P. Vinogradov, Yu. A. Surkov, G. M. Chernov, F. F. Kirnozov, and G. B. Nazarkina 26 Sep. 1966 12 p refs Transl. into ENGLISH from Geokhimiya (Moscow), no. 8, 1966 p 891–899 (Contract NAS5-12487)
(NASA-CR-80147; ST-LPS-ACH-10517) CFSTI: HC $1.00/MF $0.50 CSCL 03B

Preliminary results are given of measurements of gamma-radiation of the lunar surface carried out with a scintillation gamma-spectrometer installed on board Luna-10. These measurements covered continental as well as mare regions on both the visible and far side of the Moon. The energy range of the spectra was from 0.3 to 3.1 Mev, and the integral gamma-emission registered at some 15 points was in the same energy range. From the comparison of lunar gamma-spectra with the standard (calibration) spectra for various types of rocks it could be concluded that rocks with the same K, Th and U content as in terrestrial acid rocks (of granite type) are absent in the regions of the lunar surface where measurements were taken. Judging from the experimental data on the intensity of gamma-radiation at the expense of natural radioactivity, it may be referred to the level of intensity from basic type rocks (of basalt type). The obtained levels of concentration of natural radioelements were somewhat overrated. It is interesting to note that tektites, as bodies close in their composition to acid rocks, evidently cannot have a lunar origin. Author

N67-13019*# Marshall Labs., Torrance, Calif.
SURVEYOR EJECTA DETECTOR MODEL ML 256-1 AND 185-1 AND SURVEYOR EJECTA DETECTOR GROUND SUPPORT EQUIPMENT MODEL ML 260-1 Final Engineering Report
R. Carden, D. Rose, H. Rosenberg, and D. Sassa [1966] 159 p (Contract NAS5-3417)
(NASA-CR-79306; ML/TN-2300.55) CFSTI: HC $5.00/MF $1.00 CSCL 22D

The design philosophy and detailed engineering analyses are presented on the ejecta detector electronic instrumentation for dust particle detection on the Surveyor Lander; the ground support equipment (GSE); and the battery operated calibrate units. The instrument sensor consists of an acoustical sensor with an output proportional to, or related to, the momentum of the particle, and a thin film capacitor detector. Fabrication and test data are detailed. The functions required of the electronics packages are listed as: (1) amplify sensor signals and convert them into a binary form compatible with the spacecraft telemetry system; (2) store data until a new impact occurs and count acoustic and film signals; (3) supply inflight calibration signals; and (4) convert spacecraft power into various regulated voltages. The GSE units were built to simulate all spacecraft power and signals; to provide simulated impact signals to the sensor, and visual display of experiment outputs; and to operate on external batteries. Also supplied were three battery operated calibration units which can be plugged into the sensor electronics when the experiment is on the spacecraft to supply five additional calibration signals. M.G.J.

N67-13225*# National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
NON-DISPERSIVE X-RAY EMISSION ANALYSIS FOR LUNAR SURFACE GEOCHEMICAL EXPLORATION
J. I. Trombka, I. Adler, R. Schmadebeck, and R. Lamothe (Melpar, Inc.) Aug. 1966 80 p refs
(NASA-TM-X-55596; X-641-66-344) CFSTI: HC $2.50/MF $0.75 CSCL 22A

An instrument for use in the diagnosis of the lunar surface is described, as well as a computer program for data reduction. The advantages of using alpha particle excitation are discussed, excitation sources are considered, and detector and electronics are described. Data analysis procedures are reported, and details are given on an analytical approach, nature of the pulse–height spectrum, and formulation of the linear least square analysis. Finally, the least square technique is applied to an experimental problem. L.E.W.

N67-13228*# Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies.
AN INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS
Anthony Turkevich, Karlfried Knolle, Richard E. Emmert, Wayne A. Anderson, James H. Patterson (Argonne Natl. Lab.) et al May 1966 44 p refs Submitted for Publication Prepared in cooperation with Argonne Natl. Lab. and JPL
(Contracts NAS7-100; JPL-950750; JPL-950315; Grant NsG-127-61)
(NASA-CR-75747; EFINS-66-49) CFSTI: HC $2.00/MF $0.50 CSCL 03A

An instrument was designed and constructed that utilizes the interactions with matter of monoenergetic alpha particles for surface chemical analysis. The source of alpha particles is a radioactive nuclide such as Cm^{242}. The energy spectra of backscattered alpha particles are measured with semiconductor detectors. Other detectors (with gold foils over them to eliminate alpha particles) register protons from (α,p) reactions. Transistorized electronics provide 128-channel pulse-height analyzers for both alpha and proton spectra. The specific unit designed for the Surveyor Lunar Mission weighs less than 4 kg and uses less than 1.3 watts. Author

N67-13234*# Volt Technical Corp., Washington, D. C.
ON A POSSIBLE STRUCTURE OF THE SURFACE LAYER OF THE MOON [O VOZMOZHNOY STRUKTURE POVERKHNOSTNOGO SLOYA LUNY]
G. N. Dul'nev, Yu. P. Zarichnyak, and B. L. Muratova 22 Nov. 1966 12 p refs Transl. into ENGLISH from Izv. Vyssh. Ucheb. Zavedo., Radiofiz. (Gor'kiy), v. 9, no. 5, 1966 p 849–857
(Contract NAS5-12487)
(NASA-CR-80579; ST-LPS-RA-10539) CFSTI: HC $1.00/MF $0.50 CSCL 03B

An analytical expression has been derived for an effective thermal conduction of bodies of various structures. The solution of an inverse problem is considered, i.e., the determination of the structure of a body by an effective coefficient of thermal conduction. Consideration is also given to a possible structure of the lunar surface layer, based on the analysis of radioastronomical data relative to the parameter $\gamma=(\lambda\rho c)^{-1/2}$ and some additional assumptions. Author

N67-13243*# Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies.
THE CHEMICAL ANALYSIS EXPERIMENT FOR THE SURVEYOR LUNAR MISSION
Anthony L. Turkevich, Karlfried Knolle, Ernest Franzgrote (JPL), and James H. Patterson (Argonne Natl. Lab.) May 1966 30 p refs Submitted for Publication Prepared jointly with JPL and Argonne Natl. Lab.
(Contract NAS7-100; Grant NsG-127-61; Contracts JPL-950315; JPL-950750)
(NASA-CR-75748; EFINS-66-47) CFSTI: HC $2.00/MF $0.50 CSCL 22A

An experiment has been designed to determine the chemical composition of the lunar surface on the Scientific Surveyor soft-landing missions to the moon. The instrument employed utilizes the characteristic spectra of backscattered alpha particles and protons from (α, p) reactions to establish the elements present in a sample. The instrument can determine the amounts of most elements present in rocks with a sensitivity and accuracy of about one atomic per cent. Satisfactory analyses have been obtained of a variety of terrestrial samples. Author

N67-13497# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
LUNAR SLOPE ANGLES AND SURFACE ROUGHNESS FROM RANGER PHOTOGRAPHS
Raoul Choate *In* Mich. Univ. Proc. of the 4th Symp. on Remote Sensing of Environment Jun. 1966 p 411–432 refs (See N67-13461 04-14) CFSTI: HC $8.75/MF $3.50
(Contract NAS7-100)

Error in the estimates of large slope angles of lunar craters due to the interpretation of the dark areas in the craters in photographic prints as shadows are discussed. Recent work has demonstrated that most slopes in the Ranger impact areas have small angles. Most craters have uniform slopes with a short, nearly horizontal central portion and gently rounded rims, i.e., they have slightly modified conical cross sections. The angle of repose of lunar material as measured from maximum slope angle of talus-like slopes is probably 33° to 35° Slope angle, local relief, and surface roughness measurements indicate that the topography in the impact areas of Rangers 7, 8, and 9 probably developed from the same geomorphic processes and is at or near equilibrium. K.W.

N67-13502# Barringer Research, Inc., Natick, Mass.
STUDIES OF THE RADAR PROPERTIES OF ROCKS IN VACUUM AND THE DESIGN OF A SPECIALIZED RADAR FOR MEASURING STRATIFICATION FEATURES OF THE LUNAR AND TERRESTRIAL SURFACE
D. W. Holdsworth and A. R. Barringer *In* Mich. Univ. Proc. of the 4th Symp. on Remote Sensing of Environment Jun. 1966 p 474–487 (See N67-13461 04-14) CFSTI: HC $8.75/MF $3.50

Very high frequency radar techniques were used to detect and map subsurface discontinuities such as soil layering, rock interfaces, and such discrete bodies as ore deposits in lunar and other planetary surfaces. Experiments were carried out using various materials that might be expected to be similar to lunar rocks and soils. These materials were crushed to various sizes and measured under extremely dry and vacuum dried conditions. The loss tangents, dielectric constants, and reflectivities were measured. Experimental results substantiate the case for sounding the lunar surface in the same manner as the present sounding of polar ice caps. S.P.

N67-13662*# Bern Univ. (Switzerland). Physikalisches Institut.
STUDIES ON THE RADIOACTIVE DATING OF THE LUNAR SURFACE Final Report
P. Eberhardt and J. Geiss Aug. 1966 15 p refs
(Grant NsG-157-61)
(NASA-CR-80730) CFSTI: HC $1.00/MF $0.50 CSCL 03B

The feasibility of remote-controlled rare gas analysis was investigated in an effort to develop a simple, lightweight, rugged rare gas extraction and purification system with negligible external power consumption. A high-temperature extraction system with a chemical reaction as a heat source was examined. Thermite, a mixture of iron oxide and aluminum, was used as the energy source. Temperatures higher than 1500°C were reached, and the heat of solidification of the molten iron prolonged the period of time the sample was at high temperature. A molybdenum extraction crucible lined with titanium sponge and containing a graphite liner was used. Total weight of the system is less than 500 g, the diameter is 7 cm, and the length is 13 cm. Performance of the extraction system is discussed. K.W.

N67-14250*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
LUNAR STAY TIME EXTENSION MODULE

Charles I. Tynan, Jr. *In its* Selected Papers on Environ. and Attitude Control of Manned Spacecraft Dec. 1966 p 67-77 (See N67-14243 04-31) CFSTI: HC$2.50/MF$0.75

A contractual and inhouse research effort to develop the technology for extending man's stay time on the lunar surface is discussed. Parameters such as lunar environment, crew size, stay time, mission objectives, and integration with logistic vehicles have been considered with respect to their effect on the configuration and design of expandable modules and supporting subsystems. An expandable lunar shelter, referred to as a stay time extension module, has been designed and a full-scale laboratory model of the shelter is being fabricated. The shelter structure, subsystems, and expendables to support 2 men on the lunar surface for 8 days should weigh 1,276 pounds and be capable of being packaged in canisters attached to the base of a manned lunar excursion module for transportation to the lunar surface. Test programs to be conducted with the full-scale shelter model and samples of its wall structure should make significant contributions to the advancement of expandable structures technology for lunar shelters and other space structures applications. Author

N67-14256*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
RADAR PROPERTIES OF THE MOON
Tor Hagfors [1966] 12 p refs
(Contract NSR-22-009-106)
(NASA-CR-80849) CFSTI: HC$1.00/MF$0.50 CSCL 03B

Radar methods applied to the study of the lunar surface are reviewed, and it is noted that obtained radar data indicate a porous, undulating surface strewn with rock-like structures. The rayed craters are considered to be both rougher and denser than their surroundings. It is concluded that detailed radar observations of the landing areas of the Surveyor satellites might resolve some of the disagreement about the physical nature of the lunar surface. Radar mapping methods can be applied relatively inexpensively to the entire visible portion of the lunar surface, and the physical nature of unexplored areas can be determined through radar by simple extrapolation. Further, lunar radar mapping can be extended to planetary investigations. M.W.R.

N67-14281# Manchester Coll. of Science and Technology (England). Dept. of Physics.
LABORATORY SIMULATION OF LUNAR LUMINESCENCE Scientific Summary Report No. 2, Mar. 1965–Mar. 1966
J. E. Geake Apr. 1966 14 p refs
(Contract AF 61(052)-798)
(AFCRL-TR-66-665; AD-640495) CFSTI: HC$1.00/MF$0.50

The report concerns mainly further investigation of the proton-excited luminescence of meteoritic material. The source of the different types of luminescence from the enstatite achondrites was elucidated by neutron activation analysis, and the characteristic luminescence spectra of difference classes of meteorites were investigated. The effect of proton damage both on the efficiencies and on the spectra were investigated; it was also found that heating produces recovery from damage, and this process is being studied. TAB

N67-15043# General Electric Co., Philadelphia, Pa. Missile and Space Div.
DESIGN AND ANALYSIS OF SOLID AND HOLLOW CUBE CORNER REFLECTORS AND HOLDERS
William M. Meyers 15 Jul. 1966 77 p refs
(Contract AF 19(628)-5841)
(AFCRL-66-563; Doc.-66SD4431; SR-1; AD-640497) CFSTI: HC$3.00/MF$0.75

The report describes the design and analysis of two types of cube corner reflectors, solid and hollow. If placed on the lunar surface with the aid of suitable soft landing spacecraft optical cube corners could be used with an earth laser system for selenodetic studies of the moon. With proper sun shielding, it should be possible to operate the cube corner reflector system during 100 percent of the lunar night and approximately 30 to 50 percent of the lunar day. Considering the displacement (due to velocity aberration) of the returned signal to colocated sending/ receiving optics to the observatory by a lunar retroreflector, a maximum return is obtained using a reflector aperture of 11 centimeters for laser radiation of 7000A. The advantages and disadvantages of the hollow and solid cube corner designs are discussed. Final decision as to the one which is most suited to this application must await the outcome of environmental testing. Author (TAB)

N67-15124*# National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va.
PROBLEMS OF MAN'S ADAPTATION TO THE LUNAR ENVIRONMENT
William Letko, Amos A. Spady, Jr., and Donald E. Hewes *In its* The Role of the Vestibular Organs in Space Exploration 1966 p 25-32 refs (See N67-15121 05-04) GPO: HC $2.00; CFSTI: MF$3.35

Experimental observations indicate that with some training man should be able to maintain his equilibrium and orientation on the lunar surface. Effects of reduced gravity on the human body are reported; and relative motions of various body members while walking, loping, and sprinting are found to be quite different for the earth and lunar gravities. Not only are there large differences in amplitudes and rates of motion of these body members, but large differences in the body lean or back angle are seen as well as a large variation in back angle with rate of locomotion. These experiments indicate that man can maintain his equilibrium even while running at about 13 ft/sec; and results indicate that wearing a suit pressurized to 3.7 psi would not alter these general conclusions. Additional experiments in reduced-gravity simulators and in 1/6-g parabolic flight are considered necessary. M.W.R.

N67-15400*# Arizona Univ., Tucson.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY, NOS. 58–59
1966 80 p refs *Its* Vol. 4, Pt. 1
(Grant NsG-161)
(NASA-CR-81160) CFSTI: HC$3.00/MF$0.65 CSCL 03A

An attempt is made to interpret the Range VII photographs and to assess their impact on lunar science. First, a classification is presented of the lunar maria based on their gross structure as found from Earth-based photography. Mare Cognitum is seen to be an impact mare, its basin having been formed well before that of Mare Imbrium. The vertical structure of the maria in general at the intermediate scale is discussed based on photography at very low Sun angles and on color photography with a wide base line. Next results concerning the presence or absence of a cosmic dust layer are considered. From high-resolution color photography it is concluded that no such layer covers the Moon, although the uppermost meter or more has undoubtedly been contaminated with cosmic debris. Data on lunar craters, crater rays, and the physical and mechanical structure of upper layers of the mare floor are reviewed. S.P.

N67-15494*# Israel Program for Scientific Translations, Ltd., Jerusalem.
THE MOON
A. V. Markov *In its* Phys. of the Solar System, Vol. 3 1966 p 238-263 refs (See N67-15484 06-30) CFSTI: HC $3.00/MF $0.65

The nature of the lunar surface is studied from the standpoint of the prospective landing of men on the Moon. It is noted that the lunar surface is quite different from the surfaces of all the planets in the solar system except Mercury. Photometric and polarization properties of the highly irregular lunar topography are considered, and studies of the lunar crust temperatures using heat receivers and radio methods are described. Endogenous and exogenous hypotheses of lunar relief formation are explained, and data on the structure of the other side of the Moon obtained from rocket flights are reported. A.G.O.

N67-15993# Boeing Scientific Research Labs., Seattle, Wash. Mathematics Research Lab.
LUNAR RESEARCH ON THE MOON
Zdenek Kopal and Wayne A. Roberts Aug. 1966 34 p refs *Its* Mathematical Note No. 479
(D1-82-0562; AD-641127) CFSTI: HC$3.00/MF$0.65

An outline of our present knowledge of the composition and internal structure of the Moon and of its surface environment is given in so far as it may affect our ability to establish a lunar base, and to define objectives for investigations to be carried out there. An outline of the methods to be used in such work is also presented. It is stressed that the main objectives of the first lunar laboratory should be an investigation of the vertical structure of the surface to a depth of 100 - 1000 meters by direct methods (drilling), and down to its center by indirect methods, in order to provide a three-dimensional extension to two-dimensional prospecting of the surface from orbiting spacecraft. TAB

N67-16015* Maryland Univ., College Park. Dept. of Physics.
OPTICAL RADAR USING A CORNER REFLECTOR ON THE MOON
P. L. Bender, J. E. Faller (Joint Inst. for Lab. Astrophys.), R. H. Dicke (Princeton Univ.), P. A. Franken (Mich. Univ.), C. O. Alley et al *In its* Study of the Phys. of Laser Radiation 15 Oct. 1966 3 p refs Repr. from J. Geophys. Res., v. 70, no. 9, 1 May 1965 p 2267–2269 (See N67-16014 06-16) CFSTI: HC $3.00/MF $0.65

In the optical radar system considered, the pulsed or continuous wave laser beam is sent through a transmitting telescope which tracks the corner reflector on the moon's surface. A small part of the reflected light is collected by the receiving telescope, which also tracks the reflector. The correlator measures the light travel time to the reflector and back. A formula is given for approximating the efficiency of such a system, that is the ratio of the number of received to the number of transmitted photons. This indicates the need for a high power laser as the light source, since the expected return from the corner reflector is some 100 times stronger than that due to diffuse scattering by the lunar surface. It is also pointed out that the corner reflector and its mounting must be designed carefully in order to avoid environmental problems on the moon's surface. The passivity and the expected reliability of the corner reflector, and the high accuracy of the optical ranging are cited as the chief advantages of the system. M.G.J.

N67-16104*# Arizona Univ., Tucson.
PRELIMINARY DRAWINGS OF LUNAR LIMB AREAS, VI
Alika K. Herring 4 Aug. 1965 *In its* Commun. of the Lunar and Planetary Lab., Vol. 4, Pt. 4 1966 p 133–140 refs (See N67-16101 06-30)
(Grant NsG-161-61)

Interpretive drawings, and the rectified photographs on which they were based, are presented for Area 22 and Areas 28 and 29. These extend the west lunar limb from 30° south latitude to the south pole. N.E.N.

N67-16107*# Arizona Univ., Tucson.
WAVELENGTH DEPENDENCE OF POLARIZATION, IV: VOLCANIC CINDERS AND PARTICLES
David L. Coffeen 29 Dec. 1964 *In its* Commun. of the Lunar and Planetary Lab., Vol. 4, Pt. 4, 1966 p 157–167 refs Repr. from Astron. J., v. 70, no. 6, Aug. 1965 p 403–413 Sponsored by ONR (See N67-16101 06-30)

Five laboratory samples were measured for comparison with the moon, using a Wollaston photopolarimeter with filters near 0.36, 0.53, and 0.97 μ, having the sun as light source. Three of the samples were porous dust layers of ground volcanic cinder particles smaller than 37 μ, in fairy-castle structures. The other two were: a porous but solid lava fragment, and the same fragment covered with a fairy-castle dust layer made from the same lava. The solid lava fragment is more highly polarized than the moon, and has essentially no wavelength dependence. The wavelength and phase dependence of the lunar polarization is closely matched by the fairy-castle structures. No dependence of polarization on sample orientation was found for the volcanic materials. Differential photometry was done with the same filters using a smoked MgO layer as comparison. All samples show a linear brightness increase (in magnitudes) from 50° to 20° phase, similar to the moon. The fairy-scale structures show an appreciable opposition effect in the ultraviolet which, however, almost disappears in the green and infrared. Author

N67-16369# Illinois Univ., Urbana. Electrical Engineering Research Lab.
IONOSPHERIC RESEARCH Quarterly Progress Report, 1 Apr.–30 Jun. 1966
H. D. Webb Ft. Monmouth, N. J., Army Electron. Command, Oct. 1966 27 p
(Contract DA-36-039-AMC-03703(E))
(ECOM-03703-11; QPR-11; Rept.-11; AD-641795) CFSTI: HC $3.00/MF $0.65

Moon-reflected signals were received on 36 days for a total of approximately 378 hours at 150.6 mc and approximately 67 hours at 413.25 mc. Tables and a graph of observation times are presented. Calculations are virtually complete through the April observations. The influence of the April 15 solar flares is not evident in the data. Quarterly averages of electron content centered around March 21, June 21, and September 21 are presented. The one centered around Jun 21 shows the late afternoon maximum that appears in the summer. The gain of the 28 foot paraboloid using the sun as a source and a comparison method is 18.9 plus or minus 0.5 db. A phase-lock unit to keep the 150.6 mc receiver tuned is being built and installed as part of an automatically operated station. A coordinate converter to control the antenna was procurred. The evaluation of methods of resolving the n x 180 degrees ambiguity in lunar Faraday rotation data and the calculation of electron temperatures is being continued. The Atlas of Lunar Data for 1961 through 1964 is ready for printing Volume IV of the atlas, for 1965 data, is being prepared. Author (TAB)

N67-16587# TRW Systems, Redondo Beach, Calif.
MANNED EXPLORATION, COLONIZATION AND EXPLOITATION OF THE LUNAR SURFACE Selective Bibliography
L. R. Magnolia 10 Oct. 1966 9 p refs *Its* Lit. Survey 26
(TRW-99900-6045-T000; AD-641973) CFSTI: HC $3.00/MF $0.65

The report lists 124 references which are all available to the public. TAB

N67-16602* Stanford Univ., Calif. Radioscience Lab.
RESEARCH AT THE STANFORD CENTER FOR RADAR ASTRONOMY Semiannual Status Report, 1 Jul.–31 Dec. 1967

Jan. 1967 16 p refs
(Grant NsG-377)
(NASA-CR-81306; SASR-8) CFSTI: HC$3.00 CSCL 03A

Progress is reported in a number of theoretical and experimental investigations in radio and radar studies of space plasmas, lunar and planetary surfaces, communication theory, and spacecraft instrumentation. Of particular interest are a program of data analysis for an FM–CW lunar radar experiment and a program involved with the reception of Lunar Orbiter's S-band telemetry signals. Other areas discussed are planetary surface mapping, optical analysis of radar images, planetary atmosphere and ionosphere, signal processing, a solar radar program, signal channel coding schemes, and electron density determinations. C.T.C.

N67-16603*# Boeing Co., Seattle, Wash. Space Div.
A STUDY OF THE LUNAR ORBITER REGARDING ITS ADAPTABILITY TO SURFACE EXPERIMENTS UTILIZING A FLY-BY AND EARTH RETURN TRAJECTORY Final Report
6 Oct. 1966 118 p
(Contract NAS1-6216)
(NASA-CR-66269; D2-100690-4; L-6753) CFSTI: HC $3.00/MF $0.65 CSCL 22C

The lunar flyby and earth return trajectory was duplicated closely using Lunar Orbiter trajectory programs. Targeting the Atlas/Agena booster for this specific trajectory requires that: (1) the Agena use a long coast, between 1/2 and 1 orbit, and (2) launch time and azimuth be tied to a single value; this reduces the customary launch window of 2 to 4 hours. Major conclusions are that the trajectory could be flown by the Lunar Orbiter, but other free-return trajectories not constrained to a specific time would be easier. Accuracy obtained with Lunar Orbiter is adequate with two midcourse corrections each way; requirements being 211 m/second out of an available 912 m/second. Tracking and orbit prediction capability of MSN could be fully exercised with no change to Lunar Orbiter or MSN if spacecraft command and control is left with DSIF and SFOF at Pasadena. The mission plan must take into account thermal, power, communication, video transmission, and DSIF and MSN tracking requirements. An additional 64 pounds could be carried on the mission without off-loading propellant, and the spacecraft could be placed into an earth orbit upon return instead of reentering and being destroyed by using the unspent propellant. C.T.C.

N67-16611* Douglas Aircraft Co., Inc., Santa Monica, Calif. Missile and Space Systems Div.
EXPERIMENTAL INVESTIGATION OF ULTRA-HIGH VACUUM ADHESION AS RELATED TO THE LUNAR SURFACE Quarterly Progress Report, 1 Oct.–31 Dec. 1966
J. A. Ryan 26 Jun. 1964 26 p ref
(Contract NAS7-307)
(NASA-CR-81348; QPR-10) CFSTI: HC$3.00 CSCL 22A

Studies have been concerned with measurements of adhesion between various silicate minerals whose surfaces have been formed by cleavage in ultrahigh vacuum, and with modifications in the present experimental apparatus to provide further information as to the nature of the adhesional forces acting. Of particular note is the highly varied behavior of the long range attractive force which has become more evident. This force field appears often to be anisotropic on a macroscopic scale, forcing the samples into their pre-cleavage orientation even when a significant mismatch is initially present. An electrometer probe is being fabricated for installation in the vacuum system. This probe will be used to obtain plots of the charge distribution over the surface. Author

N67-16619*# Northrop Space Labs., Hawthorne, Calif.
DEVELOPMENT OF TECHNOLOGICAL CONCEPTS LEADING TO THE BENEFICIAL USE OF LUNAR MAGMA PRODUCTS Technical Progress Report, Oct.–Dec. 1966
E. Azmon Dec. 1966 4 p
(Contract NAS7-358)
(NASA-CR-81339) CFSTI: HC$3.00/MF $0.65 CSCL 08D

It is reported that effort was concentrated on the analysis of gabbro and serpentine, on the completion of analysis of an artificial olivine, and on determining the petrographic properties of cast and formed geometric shapes. A pressure versus temperature genesis diagram for gabbro, and photographs of cast basalt and obsidian dust are included. C.T.C.

1966
IAA ENTRIES

A66-16783 #
DEPTH OF THE LUNAR DUST.
Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Journal of Geophysical Research, vol. 70, Dec. 15, 1965, p. 6129-6138. 18 refs.

The appearance of laboratory craters overlain by various thicknesses of sand has been compared with that of lunar craters, 3 to 13,000 meters in diameter, shown in ten photographs obtained by the Ranger 7 spacecraft. Results obtained are consistent with an interpretation that at least 5 meters of granular material, and probably considerably more, is deposited on the area of Mare Cognitum shown in these photographs. (Author)

A66-16784 #
STRENGTH OF THE LUNAR DUST.
Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Journal of Geophysical Research, vol. 70, Dec. 15, 1965, p. 6139-6146. 8 refs.

Determination of the strength of the overlay of granular material on the moon. Lunar surface material must have at least enough strength to permit maintenance, against lunar gravity, of the crater wall slopes and heights observed in the Ranger 7 photographs. These photographs showed craters that appeared to be fully covered with dust and, at the same time, that had fairly steep slopes. Specific criteria used were: (1) crater image large enough to permit reasonably accurate measurements; (2) uniform round shape with no obvious irregularities within crater or at rim; (3) soft appearance suggesting substantial dust cover; (4) brightness of crater sides similar to that of bottom, rim, and surrounding terrain; and (5) shadow pattern suggesting fairly steep slopes. Slopes and heights in craters which appear to be overlain with granular material permit setting lower bounds to its strength. The lower bound for the mass bearing capacity is 10 g/cm^2 on a strip of 0.1 m width, and 100 g/cm^2 on a strip of 1 m width. M.F.

A66-16788 #
BEARING STRENGTH OF "FAIRY CASTLE" STRUCTURES.
Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Journal of Geophysical Research, vol. 70, Dec. 15, 1965, p. 6268-6270. 10 refs.

Measurements of bearing strength of the lunar surface. To explain the optical properties of the lunar surface, Hapke and Van Horn suggested that the outer layer is made up of rock particles, a few microns in diameter, which maintain a very high porosity by interparticle adhesion. They termed this a "fairy castle structure." The materials used were silica and alumina. Cohesion was measured by determining the height of vertical cut that the material would maintain for a short time. The cohesion was found to be about 5×10^2 $dynes/cm^2$ for all samples. The measured bearing capacities are tabulated. It is evident from the table that the bearing capacity of the fairy castles depends very strongly on the percent solid. Conditions used in these tests differ from those of interest on the moon in three important respects: bearing size, gravity field, and atmosphere. The values calculated from test results provide only lower bounds for the strength of fairy castles under lunar surface conditions. M.F.

A66-17456
STRUCTURES INSIDE A LUNAR CRATER PHOTOGRAPHED BY RANGER VII.
Vern G. Smalley and Luciano B. Ronca (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Nature, vol. 208, Dec. 4, 1965, p. 930-933.

Investigation of the origin and nature of three structures in a 235-mi lunar crater. The structures were revealed in frame number 199 of Ranger 7's (1964 41A) camera A. Three-dimensional clay models, tonal contour maps, and over-exposed under-developed prints were used to study the features. On the basis of the structure determined for the three features, it is thought that impact is an unlikely explanation for their origin. Endogenous activity is considered the most likely mechanism. R.A.F.

A66-17729 #
THE DIRECTIONAL RADIATIVE CHARACTERISTICS OF CONICAL CAVITIES AND THEIR RELATION TO LUNAR PHENOMENA.
Leslie G. Polgar and John R. Howell (NASA, Lewis Research Center, Cleveland, Ohio).
American Institute of Aeronautics and Astronautics, and Institute of Navigation, Astrodynamics Specialists Conference, Monterey, Calif., Sept. 16, 17, 1965, Paper. 16 p. 13 refs.

Analysis of the directional radiative characteristics of a right circular conical cavity, having diffuse gray walls, in order to compare the results with the reflective characteristics of the moon. A beam of parallel solar radiation is considered as impinging upon the cavity at a certain angle, and a Monte Carlo analysis is used to determine the directional reflectivity of the cone. The parameters varied are the cone angle, surface absorptivity, and the angle of incidence of the solar radiation. The directional receptivity of a right circular cone with a 30^o cone angle and a surface absorptivity of 0.5 is found to compare well with experimental photometric results for the lunar surface. Implications of this result, for ascertaining the nature of the lunar surface, are noted. P.K.

A66-18090
OBSERVATIONAL MANIFESTATIONS OF THE INTERACTION OF THE LUNAR SURFACE WITH INTERPLANETARY SPACE.
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).
IN: PLASMA SPACE SCIENCE SYMPOSIUM, CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, D.C., JUNE 11-14, 1963, PROCEEDINGS. [A66-18072 07-30]
Edited by C. C. Chang and S. S. Huang.
Dordrecht, Netherlands, D. Reidel Publishing Co., 1965, p. 317-323; Discussion, p. 324-331. 9 refs.
Contract No. AF 61(052)-380.

Discussion of the nature of the energy source that is responsible for the luminescence of the lunar surface. Results of photographic (narrow-band filter) and spectrographic observations are examined to determine the extent to which such factors as the solar wind, solar corpuscular radiation, solar electromagnetic radiation, and radioactivity of the lunar surface can contribute to lunar luminosity. It is seen that it will not be possible to answer the question of the source of lunar luminosity with any certainty until indications of luminosity on the dark side of the moon have been obtained. Of great significance is seen to be the discovery by Manchester astronomers that during the day the surface of the moon emits luminous radiation, with indications of band structure, of an intensity of up to 9% of the ambient continuum; the intensity is not uniform over the lunar surface (indicating that the surface is composed of different materials) and also varies with time. These data, however, are still too sparse to permit a correlation of the fluctuations with any specific aspect of solar activity. V.P.

A66-18265
TOPOGRAPHY OF THE MOON.
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).
Space Science Reviews, vol. 4, Sept. 1965, p. 737-855. 101 refs.

Outline of methods for determining the exact shape of the lunar surface from observations which can be made from the earth, and brief discussion of the results that have so far been obtained by their application. The global form of the moon, the definition of lunar coordinates, and relative coordinates on the moon and their determination are considered, and a descriptive survey of formations

on the lunar surface is provided. Other subjects discussed are the origin of lunar formations, the lunar surface as an impact counter, and lunar stratigraphy. The optical librations of the moon are treated in an appendix. M.M.

A66-18733

SPECTRAL RESPONSE OF RANGER TV CAMERAS - MEASUREMENT AND USE.

L. Herczeg (Radio Corporation of America, Defense Electronic Products, Astro-Electronics Div., Princeton, N.J.).

IN: SPACE ELECTRONICS.

Camden, N.J., Radio Corporation of America, 1965, p. 34-39.

All of the parameters of the Ranger TV cameras are fixed, and the electrical output of the cameras depends only on the luminance of the lunar scene. This output must be known in order to set the gain of the video amplifiers. However, a problem arises in that there is no usable source which approximates the moon's spectral distribution and luminance; therefore, some other source must be used, and, based on its spectral distribution, its luminance will be set to provide the same output from the camera as would be provided if the lunar scene were observed. This paper describes the method for determining the luminance of this artificial source; also discussed are methods for measuring the spectral response of camera systems. (Author)

A66-18768

LUNAR EXPERIMENTS - THE MOON AS A SITE FOR CERTAIN PHYSICAL MEASUREMENTS.

R.D. Hill (Defense Research Corp., Santa Barbara, Calif.).

Science, vol.151, Jan. 14, 1966, p.195, 196. 6 refs.

Discussion of the surface of the moon as an ideal location for conducting certain experiments with elementary particles. If the lunar surface becomes available for conducting physical experiments it may be suited to thermal neutron, molecular, and atomic beam measurements. The possibilities of applying these beams to communication on the moon's surface are discussed and it is shown that ample particle intensities could be received at distant detectors; therefore, information could be transmitted between any two stations on the surface of the moon. D.P.F.

A66-19264

THE SELENODETIC CONTROL SYSTEM OF THE AERONAUTICAL CHART AND INFORMATION CENTER OF THE U.S. AIR FORCE.

C. L. Goudas (Boeing Co., Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).

Icarus, vol. 4, Dec. 1965, p. 528-543. 25 refs.

Values of the coefficients J_{ij} and J'_{ij} of the expansion into spherical harmonics of the surface of the moon as this is presented by the Selenodetic Control System of the Aeronautical Chart and Information Center (ACIC) of the USAF are derived. Data for the Marginal Zone are taken from the maps of Watts and Hayn and the measurements of Davidson and Brooks. It is found that the present values are in good agreement with those derived on the basis of the same data derived by Schrutka-Rechtenstamm and the Army Map Service. The ACIC Control System approximates best the figure of the Moon as this is derived from the study of its physical libration on the assumption of homogeneity. (Author)

A66-19265

A NOTE ON LUNAR RAY SYSTEMS.

T. W. Rackham (Manchester, University, Dept. of Astronomy, Manchester, England).

Icarus, vol. 4, Dec. 1965, p. 544-546.

Comments on certain lesser ray systems on the moon. A description is given of the crater Delambre and of the area north of Bonpland J, according to photographs taken with the aid of Ranger spacecraft. An attempt is made to count the number of craters and craterlets in these areas of the moon. A.B.K.

A66-19417 #

LUNAR CRATER DISTRIBUTION FROM THE RANGER 7 PHOTOGRAPHS.

Robert T. Brinkmann (Florida, University, Dept. of Physics and Astronomy, Gainesville, Fla.).

Journal of Geophysical Research, vol. 71, Jan. 1, 1966, p. 340-342. Grant No. NsG-429-S-1.

Extension of the work of Miller on lunar crater distribution, from earth-bound telescopic data and analysis of the Ranger 7 photographs. The validity of Miller's suggestion that secondary craters are present in significant abundance in the smaller sizes is reaffirmed. An approximate expression is derived for the secondary distribution corresponding to a primary distribution. It is noted that the lunar surface should be markedly different from the surface of a meteorite, since the moon retains most of the mass blasted loose by impacting particles whereas a meteorite does not. The "stirring" of the lunar surface would soon produce a layer of matter darkened by exposure to the solar wind and UV radiation and extending to a depth approximately equal to the penetration of the micrometeorites.

A66-19458 #

AN EXPERIMENT IN INFRARED SPECTROPHOTOMETRY OF SATELLITES - THE MOON AND THE GALILEAN SATELLITES OF JUPITER [OPYT INFRAKRASNOI SPEKTROFOTOMETRII SPUTNIKOV - LUNA I GALILEEVSKIE SPUTNIKI IUPITERA].

V. I. Moroz (Moskovskii Gosudarstvennyi Universitet, Gosudarstvennyi Astronomicheskii Institut, Moscow, USSR).

Astronomicheskii Zhurnal, vol. 42, Nov.-Dec. 1965, p. 1287-1295. 19 refs. In Russian.

Spectrophotometric study of selected areas of the moon, using a prismatic infrared spectrometer and a 125-cm reflector in the range from 0.8 to 3.8 μ and of the Galilean satellites of Jupiter, using this same spectrometer and 125- and 260-cm reflectors in the range from 0.8 to 2.5 μ. From an analysis of the spectra obtained for the sections of the lunar surface, it is found that the increase in albedo with wavelength, at least up to 2.2 μ, is approximately identical for all the areas investigated. Among terrestrial materials observed, volcanic ash and slag are found to show a similar dependence of albedo on wavelength. Thermal radiation is seen to make a considerable contribution in the range from 3 to 4 μ. The temperature of the subsolar point, as determined from the thermal excess, is found to be 395°. The recordings obtained for Europa and Ganymede, two of the Galilean satellites, show details characteristic of the reflection spectrum of a snow layer. A.B.K.

A66-20114 #

INVESTIGATION OF THE SURFACES OF THE MOON AND PLANETS BY THE THERMAL RADIATION.

V. S. Troitsky (Gorki State University, Institute of Radiophysics, Gorki, USSR).

(Symposium on Planetary Atmospheres and Surfaces, Dorado, Puerto Rico, May 24-27, 1965, Paper.)

Journal of Research, Section D - Radio Science, vol. 69D, Dec. 1965, p. 1585-1611; Discussion, p. 1611, 1612. 95 refs.

In the present paper the attempt is made to summarize the numerous data, experimental and theoretical, of the investigation of the lunar and planetary surfaces based on their thermal radiation and to consider it from a common standpoint following from the physical principles discussed in this study. Accordingly, in the first part a brief theory is set forth of the methods for investigating the properties of planetary material. Secondly the results are given obtained by their application to the emission of the moon. (Author)

A66-20173

A FOURTH STATE OF MATTER ON THE SURFACE OF THE MOON?

R. O. Kapp.

Space/Aeronautics, vol. 45, Jan. 1966, p. 130, 132, 134, 136, 138, 140.

Examination of certain lunar phenomena which lead to the conclusion that the lunar surface consists of a solid substance with mechanical properties quite different from those of terrestrial rock. The craters shown in the Ranger photographs indicate the lunar surface has a very low mechanical strength. That these craters should have been formed by the random impact of meteorites is found to be an untenable hypothesis. The craters bear a striking resemblance to terrestrial craters; this kind of formation could have been formed by a disturbance from below. However, such a disturbance, acting through a substantial thickness of hard

rock would produce large craters and not the many tiny craters observed on the moon. To account for these observations the existence of matter in the "infrasolid" state is postulated. In such matter the average distance between constituent molecules has increased with time. D. P. F.

A66-20286
THE LUNAR ENVIRONMENT.
John W. Salisbury, Donald H. Eckhard, and Mahlon S. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).
IN: HANDBOOK OF GEOPHYSICS AND SPACE ENVIRONMENTS. Edited by S. L. Valley.
New York, McGraw-Hill Book Co., 1965, p. 19-1 to 19-16. 27 refs.

Speculative discussion of the lunar environment. It is assumed that the major portion of our space effort will be directed first toward exploration of the moon, with exploration of planets following. Figures show the distribution of lunar temperatures at various phases, a cross section of typical highland terrain, and erosion of rubble layers to reduce relief. Suggested values for lunar constants for use in computations are given. M. M.

A66-20397
STRUCTURE OF THE CRATER ALPHONSUS.
Luciano B. Ronca (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Nature, vol. 209, Jan. 8, 1966, p. 182. 7 refs.

Analysis of the crater Alphonsus on the moon, using a photograph obtained by the Ranger 9 space vehicle. The strike-slip fault on the floor of Alphonsus is studied, and three sets of lineaments present on the floor of the crater are discussed. The central peak is compared to Pelée Mountain in Martinique. It is concluded that Alphonsus is a crater deformed by a strike-slip fault of dextral type. B. B.

A66-20885
DETECTABILITY OF LUNAR X-RAYS.
R. C. Haymes and R. D. Juday (William Marsh Rice University, Space Sciences Dept., Houston, Tex.).
Planetary and Space Science, vol. 13, Dec. 1965, p. 1249-1254. 17 refs.
Grant No. AF AFOSR 858-65.

We have examined several theories that imply the generation of X rays by the moon. The X-ray fluxes to be expected at the top of the earth's atmosphere are estimated and compared. For example, we find that an X-ray flux is to be expected when the moon is full and K_p high, as a consequence of the configuration of the auroral electrons in space deduced from the long tail model of the magnetosphere. The X-ray photons are caused by energetic electrons in the tail that bombard the lunar surface. Alternatively, Gold has suggested that lunar X rays are produced by the bombardment by solar-wind electrons; this results in a lunar phase dependence that is different from the long tail model. The background is discussed and we conclude that the lunar X-ray flux may be detectable. Experiments of this kind may provide useful tools for investigating the models. (Author)

A66-21203
SHAPE AND INTERNAL STRUCTURE OF THE MOON.
D. L. Lamar (Earth Science Research Corp., Malibu, Calif.) and Jeannine McGann (RAND Corp., Santa Monica, Calif.).
Icarus, vol. 5, Jan. 1966, p. 10-23. 33 refs.
USAF-supported research.

Demonstration that the gross shape of the moon may be related to the distribution of continents and maria, and that the relationship between shape and moments of inertia is such that density variations unrelated to the distribution of continents and maria must occur in the moon's interior. The nature of the density variations is determined for two models of internal structure: (1) the moon is assumed to be a rigid body not in isostatic equilibrium; the density variations are assumed to be the result of randomly distributed inhomogeneities, and (2) the moon is assumed to be in isostatic equilibrium, and differences in elevation are assumed to be compensated by variations in crustal thickness; the required density variations beneath the crust are assumed to be the result of temperature differences. It was found that both models are consistent with current knowledge of the moon. F. R. L.

A66-21210
NOTE ON "SHAPE AND INTERNAL STRUCTURE OF THE MOON" BY LAMAR AND McGANN.
C. L. Goudas (Boeing Co., Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).
Icarus, vol. 5, Jan. 1966, p. 99, 100. 11 refs.

Discussion of the attempt by the cited authors to establish that the density distribution of the moon cannot be homogeneous because the ellipsoidal component of the moon's figure and the ellipsoid of inertia are not similar. Recent data, considered to be more reliable than those used by these authors, are said to suggest that the hypothesis they developed is not compatible with measurements. F. R. L.

A66-21532
THE POSSIBLE APPLICATION OF REMOTE GEOCHEMISTRY IN PLANETARY EXPLORATION.
A. R. Barringer (Barringer Research, Ltd., Toronto, Canada).
IN: SCIENTIFIC EXPERIMENTS FOR MANNED ORBITAL FLIGHT; PROCEEDINGS OF THE THIRD GODDARD MEMORIAL SYMPOSIUM, WASHINGTON, D. C., MARCH 18, 19, 1965. [A66-21517 10-30]
Edited by P. C. Badgley.
Washington, D. C., American Astronautical Society (AAS Science and Technology Series. Volume 4), 1965, p. 303-321. 7 refs.

Proposal of a technique for the measurement of trace amounts of vapors in the lunar and terrestrial atmospheres as an indicator of biologic and geologic surface conditions. The monatomic vapors of a number of metals, iodine vapor, and sulfur dioxide are considered, and such analytical techniques as atomic absorption and molecular absorption are discussed. The facility for the spectrophotometric analysis of light reflected from the lunar and terrestrial surfaces is described and illustrated, orbital scanning modes which could be performed with the equipment are outlined and illustrated, and methods of carrying out feasibility studies are explained. B. B.

A66-21900
SURVIVAL ON THE MOON.
Lawrence Maisak.
New York, Macmillan Co., 1966. 159 p.
$3.95.

This book predicts the conditions man will have to face when exploring the lunar surface based on the composite data now available concerning the earth's satellite. The moon's most salient surface features, topography, and gravitational effects are described. The problems of maintaining a breathable atmosphere and the possibility of water existing on the moon are discussed. Sources of lunar water might be water of crystallization in minerals, ice on the surface of craters in places permanently shielded from the sun, and connate water which has remained out of contact with the surface for a very long time. The problems connected with the hydroponic growing of plants on the moon as a source of food are discussed. Types of temporary and permanent shelters which might be constructed on the moon are considered. It is shown that the principal stress to which such dwellings would be subjected is the pressure exerted from within by the artificial atmosphere which would have to be maintained. Surface dust and meteorites are discussed; lunar temperatures and the role of radiation both as a means of regulating temperature and as hazard are analyzed. Types of spacesuits adequate for lunar travel are described in detail. Working conditions on the moon are considered in the light of the moon's reduced gravity and total lack of an atmosphere. Various possible types of vehicles for long-range lunar exploration are discussed in the light of the probable nature of lunar terrain and exploration objectives. D. P. F.

A66-21943 #
ECONOMIC IMPLICATIONS OF EXTRACTING PROPELLANTS FROM THE MOON.
R. J. Salkeld (United Aircraft Corp., Redondo Beach, Calif.).
Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 254-261.
Lunar propellant extraction is analyzed to obtain a preliminary evaluation of its potential for reducing operational costs of space activities. Expressions are derived for the cost of propellant manufacture and deployment throughout earth-moon space using both expendable and reusable tankers for propellants manufactured both on the earth and on the moon, where the lunar extraction cost per pound of propellant is a parameter. Comparisons show that expendable tankers always are preferable for earth propellants and that reusable tankers are essentially always preferable for lunar propellants. The economic advantages of lunar propellants increase with increasing distance from earth and are evident particularly for deployment and refueling in lunar orbit. The results show that, for some values of extraction costs, significant operational cost savings are possible through use of lunar propellants. Speculative estimates indicate these values may be achievable, but that considerable ranges can be estimated within the present uncertainty about technical feasibility of extraction methods. The results are essentially independent of earth launch costs, foreseeable advances in propulsion technology, and other lunar activity. Further study of this concept and its mission applications clearly seems justified, especially to determine more precisely the characteristics of the required lunar equipment and operations. (Author)

A66-21955 #
QUANTIFYING TERRAIN ROUGHNESS ON LUNAR AND PLANETARY SURFACES.
Milton Schloss (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
(American Institute of Aeronautics and Astronautics, Annual Meeting, 2nd, San Francisco, Calif., July 26-29, 1965, Paper 65-389.)
Journal of Spacecraft and Rockets, vol. 3, Feb. 1966, p. 283-285.
[For abstract see issue 18, page 2700, Accession no. A65-29372]

A66-22571 #
LUNAR DUST DEPTH IN MARE COGNITUM.
Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Journal of Geophysical Research, vol. 71, Feb. 15, 1966, p. 1095-1103. 8 refs.
Comparison of Ranger 7 photographs of lunar craters with photographs of laboratory craters for which the preparation and imagery were refined in the following ways: (1) overlay materials of varying cohesion and particle size were used; (2) collimation of the illuminating light matched that of the sun; (3) several lighting angles were used, bracketing the sun angles for all the Ranger frames considered; (4) crater images were passed through a television system at various scan line spacings, bracketing those provided by the Ranger television system for the lunar crater images. Results support the earlier conclusion that the appearance of lunar craters in the Ranger photographs is consistent with the presence of at least 5 m of granular overlay, and probably considerably more, in the area of Mare Cognitum. M.F.

A66-22964
MEASURING THE SHAPE OF THE MOON.
Robert L. Wildey (U.S. Geological Survey, Astrogeology Branch, Flagstaff, Ariz.).
Sky and Telescope, vol. 31, Mar. 1966, p. 147-150.
Discussion of various methods of determining the shape of the moon by measuring the distance from points on the lunar surface to the moon's center of mass. A number of important sources of uncertainty in lunar photogrammetry are pointed out. The possibility of using laser beams to transmit information concerning distances between points on the moon is considered. In spite of a number of formidable difficulties which must be solved, it is thought that the use of optical laser radar is feasible for this purpose. A.B.K.

A66-23193
TRANSIENT LUNAR EVENTS - POSSIBLE CAUSES.
Barbara M. Middlehurst (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
Nature, vol. 209, Feb. 5, 1966, p. 602. 7 refs.
Statistical analysis of the correlation if any between transient lunar events (luminescence) and sunspot numbers. The previous work of Flamm and Lingenfelter which concluded that 19 events in the region of Aristarchus were negatively correlated to low sunspot number, is refuted. The same events are analyzed with respect to monthly sunspot number and to the distribution of sunspot numbers from 1749 to 1964. It is concluded that no correlation of lunar events with sunspot numbers exists, and that the statistics (summarized in a table) would seem to represent a random distribution of events superposed on an asymmetric distribution of sunspot numbers. M.L.

A66-23506 #
SPECTRAL STUDIES OF THE LUNAR SURFACE [SPEKTRAL'NYE ISSLEDOVANIIA LUNNOI POVERKHNOSTI].
N. N. Petrova (Akademiia Nauk SSSR, Glavnaia Astronomicheskaia Observatoriia, Pulkovo, USSR).
Astronomicheskii Zhurnal, vol. 43, Jan.-Feb. 1966, p. 162-171. 27 refs. In Russian.
Results of spectrophotometric observations of 11 areas of the lunar surface, at the Astrophysical Institute of the Kazakh SSR. The distribution of spectral reflectivity is determined by a comparison of lunar spectra with the solar spectrum and the spectra of early star classes. The reflectivity varies almost linearly with the wavelength, and the inclination angle of the brightness coefficient is nearly equal to that of some terrestrial rock rich in quartz and other silicon oxides. Theories are proposed to interpret particular features of the lunar spectra observed. V.Z.

A66-23694
A NONDISPERSIVE X-RAY SPECTROMETER FOR LUNAR AND PLANETARY GEOCHEMICAL ANALYSIS.
Albert E. Metzger, Richard E. Parker (California Institute of Technology, Jet Propulsion Laboratory, Space Sciences Div., Pasadena, Calif.), and Jacob I. Trombka (NASA, Manned Space Sciences Div., Washington, D.C.).
(Annual Nuclear Science Symposium, 12th, San Francisco, Calif., Oct. 18-20, 1965, Paper.)
IEEE Transactions on Nuclear Science, vol. NS-13, Feb. 1966, p. 554-561. 7 refs.
Description of the application of nondispersive X-ray spectroscopy to the remote analysis of lunar and planetary surfaces. It is noted that it is possible to design an instrument which is light in weight, fast in response, can be deployed directly over an unprepared surface, and requires little power for each sample examined. An operating breadboard has been constructed and test results are presented. A computer approach to data reduction is discussed, and several specific applications of the method are proposed. M.M.

A66-23903
THE MOON AS THE PARENT BODY FOR BRONZITE CHONDRITES [DER MOND ALS MUTTERKÖRPER DER BRONZIT-CHONDRITE].
H. Wänke (Max-Planck-Institut für Chemie, Mainz, West Germany).
Zeitschrift für Naturforschung, Ausgabe A, vol. 21, Jan.-Feb. 1966, p. 93-110. 72 refs. In German.
Evaluation and analysis of experimental data to determine whether bronzite and hypersthene chondrites are of lunar or asteroidal origin. Porosity, the presence of light primordial rare gases, and the distribution of cosmic ray exposure ages are arguments which can be used in favor of an asteroidal origin for bronzite chondrites. The time distribution of bronzite chondrite falls, on the other hand, indicates a lunar origin - those with high cosmic ray exposure tend to fall in the afternoon while in those that are morning falls the He_3 and He_4 diffusion losses are higher and more frequent. The mean cosmic ray exposure age of bronzite chondrites is considerably lower than that of the hypersthene chondrites. While no isolated observation is conclusive, when all of the observations are considered together it appears that bronzite chondrites are of lunar origin while an asteroidal origin is more probable for hypersthene chondrites. D. P. F.

A66-23916
THE MOON FROM LUNA 9.
G. Fielder, L. Wilson (London, University, Observatory, Mill Hill, Middx., England), and J. E. Guest (London, University, University College, Dept. of Geology, London, England).
Nature, vol. 209, Feb. 26, 1966, p. 851-853. 12 refs.
Research supported by the Science Research Council.
Evaluation of the nature of the lunar terrain based on the photographic evidence obtained from the Luna-9 TV photographic data. An analysis of the terrain indicates that the lunar surface bears a remarkable similarity to the scoriaceous surface of an aa (Hawaii) type lava flow, but it is recognized that the surface irregularities might equally have been formed by meteoric churning. Experiments with vessels containing molten igneous rocks from which the atmosphere has been rapidly evacuated have resulted in the formation of highly vesicular material consisting of interconnected vesicles from 0.1 to 3 cm in diameter. Such material, after darkening by solar radiation, is consistent with the terrain resolved in the Luna photographs and observed lunar photometric properties. These experiments support the lava-flow hypothesis for the lunar surface.
D.P.F.

A66-23943
LUMINESCENCE ON THE LUNAR SURFACE [LUMINESZENZ AN DER MONDOBERFLÄCHE].
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).
Sterne und Weltraum, vol. 5, Mar. 1966, p. 56-61. In German.
Analysis of the possibility that the surface of the moon is luminescent. The variations in the lunar light flux with solar activity are recounted. Spectral and quantitative studies lead to the conclusion that the luminescence of the moon's surface must now be regarded as fact.
R.A.F.

A66-24033 #
DISTRIBUTION OF LUNAR CRATERS.
J. F. Byron (Liverpool, University, Liverpool, England).
The Observatory, vol. 86, Feb. 1966, p. 31, 32.
Review of Fielder's attempt to obtain a solution to the controversy about the origin of the lunar craters from a statistical analysis of the crater distribution over the lunar surface. Fielder has postulated that, if the craters are meteoric in origin, one would expect the impact craters to be randomly distributed, and to show an excess in that hemisphere of the moon that leads in its orbit, the eastern hemisphere. His results show that craters of all sizes tend to form clumpy distributions, and that there is an excess of craters in the trailing hemisphere, the western hemisphere. The crater densities for crater diameters varying from 5 to 150 km are summarized for both hemispheres. Fielder interpreted these results as evidence for the theory that the majority of craters are not of meteoritic origin. The basic assumptions of this interpretation are criticized.
M.F.

A66-24199
WHEN THE IRRESISTIBLE FORCE MEETS THE IMMOVABLE OBJECT.
Eugene Shoemaker (California Institute of Technology, Pasadena, Calif.; U.S. Geological Survey, Astrogeology Branch, Flagstaff, Ariz.).
Engineering and Science, vol. 29, Feb. 1966, p. 11-15.
General discussion of the craters caused by solid objects striking planetary masses at velocities of many km/sec. Bodies known to have struck, or nearly struck, the earth - such as Icarus, Hermes, and the Tunguska bolide of 1908 - are considered. Analysis of the degree of cratering on the moon indicates that the maria are only about a tenth as old as the earth. An explanation for the formation of tektites is advanced. Examination of the pictures from Luna 9 also yields some information about craters on the moon.
R.A.F.

A66-24235
MECHANISM OF LUNAR POLARIZATION.
J. J. Hopfield (Princeton University, Dept. of Physics, Princeton, N.J.).
Science, vol. 151, Mar. 18, 1966, p. 1380, 1381. 9 refs.
Contract No. NSR-24-005-047.
A theoretical model to explain the negative polarization of moonlight at small lunar phase angles is developed. The model is based on the polarization of light in the diffraction region bordering the geometric shadow of an opaque dielectric obstacle.
(Author)

A66-24891 #
THE BISTATIC, CONTINUOUS-WAVE RADAR METHOD FOR THE STUDY OF PLANETARY SURFACES.
G. Leonard Tyler (Stanford University, Center for Radar Astronomy, Stanford, Calif.).
Journal of Geophysical Research, vol. 71, Mar. 15, 1966, p. 1559-1567. 8 refs.
A method is described for radar mapping of the surface of a planet. It is based on the use of a bistatic, continuous-wave mode of radar operation between the earth and a spacecraft orbiting or flying by the planet. The interference pattern resulting from a plane wave illuminating the planet and the fields scattered by the planet is analyzed. It is shown that the power in this pattern contains components corresponding to a linear superposition of the elementary wavelets scattered by the surface, multiplied by a phasor. The conditions under which the elementary wavelets may be recovered from a measurement of the interference pattern are given. Matched filter detection is then used to recover the amplitude of the local currents on the surface associated with each wavelet. The response to a point scatterer is calculated. Resolutions of a few wavelengths in range and azimuth can theoretically be obtained. Analogous applications to other geophysical problems are suggested.
(Author)

A66-24892 #
STRUCTURE AND COHERENCY OF THE LUNAR DUST LAYER.
R. Smoluchowski (Princeton University, Princeton, N.J.).
Journal of Geophysical Research, vol. 71, Mar. 15, 1966, p. 1569-1574. 22 refs.
Experiments show that corpuscular radiation such as solar wind can sinter fine dust by producing displaced atoms which diffuse toward the surface of the grain. The estimated rate of churning of the topmost layer of lunar dust excludes sintering through sputtering. It follows that the dust is probably not loose but is partly coherent (0.5 dyne/particle), which increases its mechanical strength and decreases its mobility. Lower layers of dust are compacted by meteorite bombardment, and a close-packed density is probably reached at a depth of a meter or so. Loads that will not commence to sink in loose and in sintered dust are calculated.
(Author)

A66-25603
PHOTOMETRIC METHOD FOR LUNAR TOPOGRAPHY.
T. Rindfleisch (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
(Jet Propulsion Laboratory, Rep. no. 32-786, Sept. 15, 1965.)
Photogrammetric Engineering, vol. 32, Mar. 1966, p. 262-276.
A general and rigorous treatment is given of the photometric method for deriving surface elevation information from a single picture of the surface. In the course of the derivation a brief indication is given of possible photometric function symmetries yielding exact solutions to the problem. It is shown that the photometric properties of the lunar maria are sufficient to produce an exact solution but with an inherent practical difficulty. The resulting equations are then specialized to the case of lunar photography and applied to the Ranger pictures as part of a digital processing procedure. Examples of the resulting elevation maps are given.
(Author)

A66-25810
ATMOSPHERIC EXTINCTION BY DUST PARTICLES AS DETERMINED FROM THREE-COLOR PHOTOMETRY OF THE LUNAR ECLIPSE OF 19 DECEMBER 1964.
Satoshi Matsushima, John R. Zink, and James E. Hansen (Iowa, State University, Iowa City, Iowa).
Astronomical Journal, vol. 71, Mar. 1966, p. 103-110. 9 refs.
NSF Grant No. GP-4742.

Three-color photometric observations of the eclipsed moon were carried out with a 12-in. reflector during the total eclipse on Dec. 19, 1964, with the purpose of obtaining data for determining the dust content in earth's atmosphere. In order to make possible a direct comparison with similar data obtained with the same equipment during the previous eclipse (Dec. 30, 1963), the photoelectric measurements were centered principally on the Mare Crisium region, except for a part of the observations which were made near Mare Frigoris. The maximum decreases in brightness at midtotality, which amounted to 12.6, 13.8, and 15.9 mag. in V, B, and U colors, respectively, were much less than those obtained at the previous eclipse but were still considerably larger than those of a normal eclipse. As opposed to the Dec. 1963 eclipse in which no reddening effect was observed, the maximum increases of the BV and UB color indices were found to be 1.1 and 2.2 mag., respectively. Theoretical calculations of the intensity distribution in the umbral region are made for various models of the earth's atmosphere with different contents of dust and water particles. Comparisons with the observations indicate that the amount of dust and water particles at the time of the eclipse was such taht it produced an additional extinction of 0.04 mag. per air mass. The corresponding value determined for the Dec. 1963 eclipse was about 0.14 mag. per air mass. (Author)

A66-26350 #
MECHANISMS FOR LUNAR LUMINESCENCE.
E. P. Ney, N. J. Woolf, and R. J. Collins (Minnesota, University, School of Physics and Astronomy, Minneapolis, Minn.).
Journal of Geophysical Research, vol. 71, Apr. 1, 1966, p. 1787-1793. 26 refs.
Contract No. NSR-24-005-047.

The visibility of luminescence on the moon depends on the competing processes that illuminate the moon and that provide energy for luminescence. It is shown that the most favorable times for seeing luminescence are at new moon, on the far side of the moon, and during rare dark eclipses. The luminosity and color of these rare eclipses are explained. Observations supposedly of luminescence during lunar day are criticized, and only the spectroscopic evidence is taken to support the reality of luminescence. Both direct and storage processes have been considered for converting energy to luminescence. Direct processes in lunar day cannot be energized by presently known sources of particles. If indirect processes occur they may give information about the dust particles at the extreme lunar surface. (Author)

A66-27182 #
RELATIVE DEPTHS OF LUNAR RING MOUNTAINS AND CRATERS IN THE "SEA OF CLOUDS" [OB OTNOSITEL'NYKH GLUBINAKH LUNNYKH KOL'TSEVYKH GOR I KRATEROV V "MORE OBLAKOV"].
A. V. Markov (Akademiia Nauk SSSR, Glavnaia Astronomicheskaia Observatoriia, Pulkovo, USSR).
Akademiia Nauk SSSR, Doklady, vol. 167, Mar. 1, 1966, p. 63, 64. In Russian.

Verification of Baldwin's formula for determining the relation between the diameter D and the depth d of lunar craters and ring mountains in the "Sea of Clouds" near the point of incidence of Ranger VII. On the basis of photos obtained by Ranger VII for lunar craters ranging in diameter from 8 m to 67 km, it is concluded that Baldwin's formula fairly closely represents the relation between the diameter and the depth of the craters, deviations being observed only in the case of very large cirques and craters with bottoms that may have been inundated by an outpouring of lava. A. B. K.

A66-27490
LUNAR GEOLOGY.
Gilbert Fielder (London, University, Observatory, Mill Hill, Middx., England).
Research supported by the Department of Scientific and Industrial Research.
London, Lutterworth Press, 1965. 184 p.

An introduction to selenology, with the stress on its relation to geology, is offered to students of both astronomy and geology. It is shown how these two subjects might, eventually, come together through the study of the moon. Lunar altitude determinations are treated, and other basic data are discussed. Methods of measuring the heights of the lunar mountains are defined, and a systematic study of the statistics of craters is made, including the distribution according to size and depth, the number-densities, slopes, central eminences, and the shapes of ring-structures. The nature of the lunar soil and the means used to study it are treated together with lunar faults, including crater chains, rills and ridges, the pattern of faulting and the origin of maria, ring-structures and craters. M. M.

A66-27603
REMARKS ON LUNAR AND ASTEROIDAL METEORITES.
K. Sitte (Max-Planck-Institut für Kernphysik, Heidelberg, West Germany).
Zeitschrift für Naturforschung, Ausgabe A, vol. 21a, Mar. 1966, p. 231-237. 9 refs.

Based on the experimental results of Gault et al., and on the orbit calculations of Arnold, the relative strength of the contributions from impacts of bodies in solar orbit on the asteroids and on the moon has been estimated. It is concluded that the asteroidal belt accounts for at least a considerable fraction of all stony meteorites, but lunar impacts occurring at a rate of about one in a few 10^5 years cannot be ruled out. Small bodies produced in asteroidal collisions which remain orbiting in the belt can escape from it as a result of repeated "elastic" collisions by multiple scattering. Their lifetime in the belt is only about 1.4×10^5 years. Satisfactory values are found for the mass loss and for the replenishment of the debris in the asteroidal belt. (Author)

A66-27823 #
TEKTITES - THEIR NATURE AND POSSIBLE ORIGIN.
A. A. Mills.
British Astronomical Association, Journal, vol. 76, Feb. 1966, p. 73-80.

Review of recent research indicating a lunar origin for tektites. The five major types of tektites (classified according to geographical location) are reviewed. Based on potassium-40/argon-40 ratios, their ages are calculated to be between 0.6 and 34 million years. It is noted that artificial tektite-like objects have now been laboratory produced by eroding glass spheres (of the correct chemical composition) with hot gases in an arc-jet tunnel, providing evidence for two distinct melting episodes in the history of such objects. These findings, together with the fact that apparently tektites do not contain the radioactive nuclide aluminum-26 (which would result from long-term cosmic-ray bombardment), suggest a maximum space lifetime of 10,000 yr - which is not long enough for tektites to have come from another planet or from the asteroid belt. It is concluded that, whatever the precise mechanism, the evidence now available supports a lunar origin for tektites. Several tektite photographs are presented. M. L.

A66-27900
ON THE POSSIBLE ORIGIN OF THE LUNAR MARIA.
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).
Nature, vol. 210, Apr. 9, 1966, p. 188. 13 refs.

Discussion of new evidence of severely local nature concerning the origin of lunar maria. It is noted that a conspicuous asymmetry in the distribution of the maria over the lunar globe appears to be consistent with an assumption that the mare plains may constitute scars of mechanical damage wrought on the lunar hemisphere by disruptive tides of the earth when the moon entered the Roche limit. At first sight, such a hypothesis would seem to require that the maria be lowlands lying below the level of the continental areas, which is not found to be generally the case. However, the possibility cannot be ruled out that the strain to which the lunar crust may then have been exposed could have led to its cracking, and that lava was exuded to the surface to fill up the original scars. M. M.

A66-28105
COMBINATION NEUTRON EXPERIMENT FOR REMOTE ANALYSIS.

R. L. Caldwell, W. R. Mills, Jr., L. S. Allen (Socony Mobil Oil Co., Inc., Field Research Laboratory, Dallas, Tex.), P. R. Bell (Oak Ridge National Laboratory, Oak Ridge, Tenn.), and R. L. Heath (National Reactor Testing Station, Idaho Falls, Idaho).
Science, vol. 152, Apr. 22, 1966, p. 457-465. 11 refs.

Description of two neutron-analysis techniques for determining the presence of hydrogen on lunar or planetary surfaces. In addition, one of the techniques can give some indication of near-surface layering if it exists. The techniques proposed are based on the measurement of the energy of prompt and capture gamma rays, the energy and half-life of activation gamma rays, and the measurement of the rate at which thermal neutrons die away after a burst of fast neutrons. All four measurements can be performed with a single instrument. V.P.

A66-28126

A COMPARISON OF THE INFRARED SPECTRA OF THE MOON AND SIMULATED LUNAR SURFACE MATERIALS.

Richard B. Wattson (Princeton University, New Observatory, Princeton, N.J.) and Bruce W. Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N.Y.).
Astrophysical Journal, vol. 144, Apr. 1966, p. 364-368. 10 refs.
NSF-NASA-Navy-supported research; Grant No. NsG-382.

Reflection spectra of selected rock powders in the 1-2.5-μ wavelength range are compared with the Stratoscope II spectrum of Mare Tranquilitatis. The spectra of natural powders are too bright and too flat to match the lunar reflectivity, which increases with wavelength in this range. However, irradiation by 2-kev H^+ ions equivalent to approximately 10^5 years of solar-wind bombardment on the moon decreased the albedo and reddened the powders markedly in the infrared. Similar effects have been previously observed in the visible. A sample of powdered chondrite was not reddened by irradiation. The infrared reflectivities of the powders are too high even after irradiation, although their visible albedos are similar to the moon's; a possible explanation is that the radiation-altered layer is optically thick in the infrared on the lunar surface but not on the laboratory samples. (Author)

A66-28179 #

ENVIRONMENTAL TEST CRITERIA FOR LUNAR AND PLANETARY SOILS.

R. W. Johnson (General Electric Co., Missile and Space Div., Philadelphia, Pa.).
Astronautica Acta, vol. 11, July-Aug. 1965, p. 252-260. 32 refs.

Review of the results of a study of lunar soil environment based on simulated soil and space environment models. Soil particle size and nature, clay as a soil constituent, soil hydrothermal alteration processes, and cohesion, adhesion, vacuum, temperature, gravity, and radiation effects are the aspects discussed at length. The current limitations in the use of simulated model techniques for the study of lunar soil environment are specified. Planetary soils are treated briefly. V.Z.

A66-28180 #

THE EFFECT OF VACUUM ON THE SHEAR STRENGTH OF AN IDEALIZED GRANULAR MEDIUM.

L. R. Hill and A. S. Cakmak (Princeton University, Dept. of Civil Engineering, Princeton, N.J.).
Astronautica Acta, vol. 11, July-Aug. 1965, p. 261-267. 9 refs.

Experimental study of the shear strength of idealized granular media in vacuum, in conditions simulating environmental pressure conditions of the lunar surface layer. The behavior of shear strength in vacuum is given theoretical consideration. The test apparatus with its vacuum system, the test material, and the test procedure are described. The results indicate that an increase in the friction coefficient of individual granules in randomly packed assemblies of equal porosity leads to an exponential increase in the shear strength of such assemblies. The lunar surface layer is expected to have a bearing strength more than sufficient for space vehicle landings. V.Z.

A66-28336 #

SPECTRUM ANALYSIS OF TERRAIN OF MARE COGNITUM.

R. M. Jaeger and D. J. Schuring (General Motors Corp., Defense Research Laboratories, Santa Barbara, Calif.).
Journal of Geophysical Research, vol. 71, Apr. 15, 1966, p. 2023-2028. 7 refs.

The roughness of a portion of the lunar surface in Mare Cognitum is analyzed and compared with the roughness of the earth's surface in two previously measured areas. A two-dimensional random walk is taken on a contour topographic map produced from photograph P979 provided by Ranger 7. The resulting lunar elevation profile is treated as a realization of an ergodic, stationary time series and is analyzed in the spatial frequency domain by use of estimates of power-spectrum density. Similar estimates are presented for the Perryman test course at Aberdeen Proving Ground, for a grass runway, and for the Bonito lava flow, Arizona, to provide some basis for roughness comparison. The Aberdeen and Mare Cognitum spectrums are shown to be comparable in basic shape but significantly different in power in certain frequency ranges. An appendix presents a summary of the mathematical methods utilized. (Author)

A66-28572

MICROWAVE COLOR OF THE EARTH AND THE MOON.

Isadore Katz (Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Md.).
IN: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, 1965 INTERNATIONAL ANTENNA AND PROPAGATION SYMPOSIUM, WASHINGTON, D.C., AUGUST 30-SEPTEMBER 1, 1965. PROGRAM AND DIGEST. [A66-28566 15-09]
Symposium supported by the U.S. Air Force and the U.S. Navy. New York, Institute of Electrical and Electronics Engineers, Inc., 1965, p. 52-55. Abridged.

Study of the wavelength dependence of the radar reflectivity of land and sea surfaces. It is found that natural and man-made surfaces show a distinct variation of radar cross section with change in electromagnetic wavelength. Relationships among depression angle, cross section, and type of surface are determined. This study draws on results of various experiments at several laboratories and is part of a larger program aimed at determining radar parameters suitable for remote sensing of earth and lunar surfaces from satellites. R.A.F.

A66-28681

LOCAL CHANGES IN THE LUNAR SURFACE CAUSED BY "SOFT" LANDINGS AND ESPECIALLY BY THE LUNA-9 LANDING [LOKALE VERÄNDERUNGEN DER MONDOBERFLÄCHE BEI "WEICHEN" LANDUNGEN SPEZIELL DER LUNA-9-LANDUNG].

Evan Harris Walker (Miami, University, School of Environmental and Planetary Sciences, Coral Gables, Fla.) and Lothar W. Bandermann (Maryland, University, Dept. of Physics, College Park, Md.).
Astronautik, vol. 3, Mar.-Apr. 1966, p. 43-45. 6 refs. In German.
Grant No. NGR-10-007-011.

Consideration of the hypothesis that the rocket exhaust of Luna 9 caused the formation of the shallow crater visible in the photographs taken by this lunar probe and also that the exhaust blew away the upper layer of dust and granular material. The photographs taken by the Ranger-7 lunar probe and the clouds of dust associated with the impact of Lunik 2 and Luna 5 are cited as evidence in favor of the existence of a dust layer on the lunar surface. The mechanism of dust and particle stripping from the lunar surface under action of the exhaust gases from Luna 9's rocket is examined. It appears that the difference between a crater produced by impact alone and one formed by the continued action of rocket exhaust gases is that in the latter case the dust and other surface detritus is expelled to a greater distance. D.P.F.

A66-28741 #

AN APPRECIATION OF THE LUNA 9 PICTURES.

Eugene M. Shoemaker, Raymond M. Batson, and Kathleen B. Larson (U.S. Geological Survey, Astrogeology Branch, Flagstaff, Ariz.).
Astronautics and Aeronautics, vol. 4, May 1966, p. 40-50.

Preliminary analysis of the Luna 9 pictorial data. A detailed description is given of the Luna 9 spacecraft and instrument capsule. The Luna 9 imaging system is discussed, and an analysis is made of the sequence of image transmissions from the moon. Problems involved in the construction of a mosaic panorama of Luna 9 pictures are considered, emphasizing the need to determine the angular fields of view and to relate the vertical to the azimuthal angular dimensions of the pictures. The orientation of the capsule and of the imaging system with respect to the lunar surface is discussed, and an approximate solution for the position of the zero parallel is obtained. The structure of the local lunar surface, as portrayed in the Luna 9 pictures, is described. It is concluded tentatively that the near-field part of the Luna 9 pictures shows the upper surface of a debris layer with an average thickness of 1 to 2 m that probably blankets most of the maria and upland regions of the moon.
A. B. K.

A66-29257
LUNAR HISTORY AS SUGGESTED BY THE CIRCULARITY INDEX OF LUNAR CRATERS.
Luciano B. Ronca and John W. Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Icarus, vol. 5, Mar. 1966, p. 130-138. 7 refs.

A quantitative way of measuring the circularity of lunar craters, the circularity index, is defined. Frequency curves of the circularity indexes of 86 craters reveal that two populations of craters are definable, one more circular than the other. The most likely explanation proposed is that the subcircular craters were formed during a period of stress in the lunar crust. (Author)

A66-29260
SOME COMMENTS ON GEHRELS' MODEL OF THE LUNAR SURFACE.
Bruce Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N. Y.).
Icarus, vol. 5, Mar. 1966, p. 154-159; Comments, Thomas Gehrels (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.), p. 160, 161. 21 refs.
Grant No. NsG-382.

Objections to the model put forward by Gehrels, Coffeen, and Owens in 1964 to explain their observations on the wavelength dependence of the optical properties of the lunar surface. This model consists of an optically thin layer of micron-sized particles electrostatically suspended over a darker surface in such a manner that the average distance between particles is about 10 times their radii. Hapke's objections have to do with the electrostatics of lunar particles and the optical properties of the layer. Gehrels replies that most observations in lunar and asteroidal photometry and polarimetry can be explained with a tenuous surface texture with interconnected (rather than freely suspended) scattering elements or particles. R. A. F.

A66-29262
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. II - APPROXIMATE DISTRIBUTION OF DIAMETER OF ALL OBSERVABLE CRATERS.
A. H. Marcus.
Icarus, vol. 5, Mar. 1966, p. 165-177. 14 refs.
Contract No. AF 49(638)-700.

It is assumed that the number density of lunar craters evolves because of the arrival of new craters and the obliteration of earlier craters by the formation of more recent ones nearby. Approximations are developed which permit the calculation of the expected number density of all observable lunar craters as a function of crater diameter and of time. This result is applied to the meteoroidal impact hypothesis for the origin of lunar craters. It is shown that obliteration alone is not sufficient to explain observed crater diameter distributions. (Author)

A66-29263
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. III - FILLING AND DISAPPEARANCE OF CRATERS.
A. H. Marcus.
Icarus, vol. 5, Mar. 1966, p. 178-189. 21 refs.
Contract No. AF 49(638)-700.

A previous model is extended to include the effects of the disappearance of craters due to filling by dust or lava. Both the age distribution and expected number density of lunar craters are obtained as functions of crater diameter and of time. These results are applied to the meteoroidal impact hypothesis of the origin of lunar craters. Good agreement is obtained with observed number densities on the lunar continents and maria. It is assumed that the rate of filling of craters on the continents corresponds to the rate of meteoritic accretion, and the rate of filling on the maria is 50 to 100 times larger than on the continents, corresponding to filling of mare craters by lava. (Author)

A66-29264
A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. IV - ON THE NONRANDOMNESS OF CRATER CENTERS.
A. H. Marcus (Case Institute of Technology, Cleveland, Ohio).
Icarus, vol. 5, Mar. 1966, p. 190-200. 15 refs.

Examination of the validity of a statistical test of randomness applied to lunar-crater data. The inherent nonrandomness of the distribution of observable craters is discussed, along with the distribution of crater density. The effects of inhomogeneity of the lunar surface are considered. Verification of the analysis from empirical crater counts is described. R. A. F.

A66-29265
THE NATURE OF SECONDARY CRATERS PHOTOGRAPHED BY RANGER VII.
Zdeněk Kopal (Boeing Co., Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).
Icarus, vol. 5, Mar. 1966, p. 201-213.

Analysis of the frequency distribution of the secondary (10 to 1000 m) lunar craters in the region of Mare Cognitum, as determined by Shoemaker (1965) and others from photographs secured by Ranger 7 in July 1964. It is hypothesized, on the basis of the analysis, that a large fraction of these depressions, counted by Shoemaker and others as craters due to secondary impacts, are in reality subsidence formations, possibly triggered by "moonquakes" which are expected to occur in the wake of all major primary impacts on the moon.
R. A. F.

A66-29657
SURVEYOR I - PRELIMINARY RESULTS.
Science, vol. 152, June 24, 1966, p. 1737-1750.

Preliminary analysis of scientific data received from Surveyor 1 during its first five days on the moon. The instrumentation of the craft is described, and the mechanical properties, thermal properties, and topography of the lunar surface are considered.
R. A. F.

A66-29974
ON THE INAPLICABILITY OF BALDWIN'S RELATION FOR THE DETERMINATION OF THE CAUSES OF LUNAR CRATERS.
G. S. Shteinberg (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Institut Vulkanologii, Kamchatka, USSR).
(Akademiia Nauk SSSR, Doklady, vol. 165, Nov. 1, 1965, p. 55-57.)
Soviet Physics - Doklady, vol. 10, May 1966, p. 1006-1008. 14 refs.
Translation.
[For abstract see issue 05, page 764, Accession no. A66-15332]

A66-30629
MARINER IV AND CRATERS ON MARS.
E. J. Öpik.
Irish Astronomical Journal, vol. 7, June-Sept. 1965, p. 92-104. 16 refs.
Grant No. NsG-58-60.

Study of the registration of craters on the planet Mars by Mariner 4. Impact craters on the surface of a planet can be classified as belonging to two categories: primeval craters and later craters. On Mars, as far as the Mariner 4 pictures go, there is no indication of any areas where the primeval craters are preserved. Anders proposes that the Martian craters are not older than 800 million years and that earlier craters, primeval or of later origin, were erased completely. The role of erosion, in particular aeolian erosion, is discussed. The Martian crater diameters are evaluated. The Mars and lunar maria are compared. The number of Martian later craters is estimated from the pictures. It is concluded that even for a time interval of 4500 million years there are no good theoretical reasons to expect a very large density of later craters on Mars. The Mariner 4 photographs are reviewed. M.F.

A66-30644

INDICATION OF LUMINESCENCE FOUND IN THE DECEMBER 1964 LUNAR ECLIPSE.

N. Sanduleak and Jurgen Stock (Cerro Tololo Inter-American Observatory, La Serena, Chile).

Astronomical Society of the Pacific, Publications, vol. 77, Aug. 1965, p. 237-240. 7 refs.

Evidence that the lunar surface fluoresces, obtained by observing the region of Mare Nubium continuously as it emerged from the umbra of the Dec. 19, 1964 lunar eclipse and progressed through the entire penumbra. Comparison of brightness measurements with theoretical values discloses that near the umbra there is an excess of light amounting to several tenths of a magnitude. This excess brightness is attributed to luminescence. R.A.F.

A66-30669

LUNAR CHARTING FOR PROJECT APOLLO.

Robert W. Carder and Samuel P. Scott (USAF, Aeronautical Chart and Information Center, Technical Planning Div., St. Louis, Mo.).

(Institute of Navigation, Annual National Meeting, Long Beach, Calif., June 21-23, 1965, Paper.)

Navigation, vol. 13, Spring 1966, p. 49-58.

Discussion of the USAF Aeronautical Chart and Information Center (ACIC) program to study and collect lunar data that would be useful in charting the moon. The predominant ACIC effort is concentrated on the production of a 1:1,000,000 scale series of Lunar Astronautical Charts (LAC). For planning purposes, 2,400,000 mi^2 of the lunar surface have been charted. Another 500,000 mi^2 are being charted at a scale of 1:500,000 for use in site selection of potential landing areas. F.R.L.

A66-30929 #

PHOTOMETRIC STUDIES OF DIFFUSELY REFLECTING SURFACES WITH APPLICATIONS TO THE BRIGHTNESS OF THE MOON.

Philip Oetking (Southwest Center for Advanced Studies, Graduate Research Center of the Southwest, Geosciences Div., Dallas, Tex.).

Journal of Geophysical Research, vol. 71, May 15, 1966, p. 2505-2513. 12 refs.

Grant No. NsG-269-62.

A series of light reflectivity measurements has been made on a variety of samples in a search for materials or surface textures which might reproduce the photometric properties of the lunar surface, particularly the pronounced rise of reflectivity at small phase angles. It has been found that most terrestrial substances, including standard diffusing surfaces, when observed with an instrument of small aperture, show a prominent rise in reflectivity if the direction of observation is within $\pm 5^{\circ}$ of the direction of the incident light. Experiments show that the height of the intensity peak entails complex interrelations of the particle size, shape, and optical properties of the reflector. The abrupt increase in the brightness of the lunar surface at zero phase may not be an unusual property of the moon but is one common to most substances. An airplane passenger can easily verify that this phenomenon is a common one by noting the bright zone on the ground around the shadow of the airplane. (Author)

A66-31483 #

PHENOMENOLOGICAL MACRORHEOLOGY IN LUNAR SOIL PHYSICS.

Rudolph Szilard (Denver, University, Denver Research Institute, Denver, Colo.).

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 4th, Los Angeles, Calif., June 27-29, 1966, Paper 66-516. 16 p. 18 refs.

Members, $0.75; nonmembers, $1.50.

Contract No. AF 19(628)-4797.

The lunar surface materials are classified into three major groups: lunar dust, consolidated lunar conglomerates, lunar rocks. The mechanical properties of these lunar surface materials, including their rate sensitivity, are described by rheological constants. These constants may be obtained analytically from microrheology or from rheometry using macrorheological approaches. Generally valid mathematical models are proposed by coupling basic rheological properties in parallel and in series and by considering geometrical and physical nonlinearities. The validity of the proposed mathematical models for lunar dust, consolidated lunar soil, and for lunar rock, is discussed. Methods to obtain the required rheological properties in the laboratory are outlined including a determination of the parameters influencing their variation under lunar environment. (Author)

A66-31700 #

NEW DATA ON THE STRUCTURE OF THE LUNAR SURFACE [NEUE ERKENNTNISSE ÜBER DIE STRUKTUR DER MONDOBERFLÄCHE].

Johannes Larink (Hamburg, Universität, Sternwarte, Hamburg-Bergedorf, West Germany).

Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Symposion über die Erforschung des Mondes und des Interplanetaren Raumes, Munich, West Germany, Apr. 22, 1966, Paper. 3 p. In German.

Report on lunar photographs taken by Ranger 7 and demonstrated by the American astronomer, Kuiper, at the 1964 conference of the IAU in Hamburg. The structural features of the lunar surface, as they appear on these photographs, are described in some detail. V.Z.

A66-31701 #

RESULTS AND GOALS OF LUNAR GEOLOGICAL STUDIES [GEOLOGISCHE ERFORSCHUNG DES MONDES - ERGEBNISSE UND AUFGABEN].

Kurt von Bülow (Rostock, Universität, Rostock, East Germany).

Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Symposion über die Erforschung des Mondes und des Interplanetaren Raumes, Munich, West Germany, Apr. 22, 1966, Paper. 8 p. In German.

Survey of lunar geology in the light of the latest Ranger and Luna satellite observations of the lunar surface. The advent of a new era is visualized for lunar geology. Goals for future geological studies of the moon are outlined. V.Z.

A66-32024

COMMISSION ON THE MOTION AND SHAPE OF THE MOON [COMMISSION DU MOUVEMENT ET DE LA FIGURE DE LA LUNE]. IN: TRANSACTIONS OF THE INTERNATIONAL ASTRONOMICAL UNION. VOLUME 12A - REPORTS ON ASTRONOMY.

Edited by J. C. Pecker.

London, Academic Press, Ltd., 1965, p. 219-225. 29 refs. In English and French.

Review of published work on the motion and shape of the moon. Investigations of the rotational elements and shape of the moon are described, as well as work on right ascensions and declinations, predictions of lunar occultations, theoretical work on the internal structure of the moon and its gravitational field, and a new method for the adjustment of heliometric libration observations. A.B.K.

A66-32132 #

LUNAR TOPOGRAPHY AND CARTOGRAPHY [TOPOGRAPHIE ET CARTOGRAPHIE LUNAIRES].

J.-M. Triplet (Institut Pasteur, Bureau des Longitudes, Paris, France).

L'Astronomie, vol. 80, May 1966, p. 183-189. 5 refs. In French.

Historical review of lunar cartography and a survey of the most prominent lunar topographical features. Due to the absence of a magnetic field, an astronaut on the moon's surface would have to determine his position from the configuration of the stars. The lunar atlas prepared by the USAF in 1960 is an example of the application of cartography to the research work of many investigators in constructing a detailed map of the moon's topography with contour lines for differences in elevation of only 300 m. D. P. F.

A66-32237

AVERAGING EFFECT OF ANTENNA RADIATION PATTERN IN MEASUREMENTS OF THE RADIO EMISSION OF THE MOON.

V. D. Krotikov (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).

(Radiofizika, vol. 8, no. 3, 1965, p. 453-460.)

Soviet Radiophysics, vol. 8, May-June 1965, p. 322-327. 24 refs. Translation.

[For abstract see issue 24, page 3666, Accession no. A65-36555]

A66-32344

DETERMINATION OF SELENOGRAPHIC LATITUDE AND LONGITUDE BY STAR OBSERVATIONS FROM THE FAR SIDE OF THE MOON.

Maud W. Makemson.

Journal of the Astronautical Sciences, vol. 12, Winter 1965, p. 117-122.

Consideration of the factors which will affect the determination of selenographic latitude and longitude by an astronaut landed on the moon. The selenocentric system and the lunar prime meridian are defined. The manner in which a star's geocentric coordinates can be transformed to the lunar equatorial system is described in terms of the selenocentric right ascension, the selenocentric declination, and the prime meridian hour angle. Assuming that the astronaut possesses an instrument for measuring vertical and horizontal angles, explicit details are given on the manner in which this device together with an accurate watch set to Greenwich mean time (universal time) can be used to accurately determine position. D. P. F.

A66-32942

RADIOACTIVITY OF THE LUNAR SURFACE.

Hobart W. Kraner, Gerald L. Schroeder (Massachusetts Institute of Technology, Dept. of Physics, Radioactivity Center, Cambridge, Mass.), Gilbert Davidson, and Jack W. Carpenter (American Science and Engineering, Inc., Cambridge, Mass.).

Science, vol. 152, May 27, 1966, p. 1235, 1236. 12 refs.

AEC Contract No. AT(30-1)-952.

Observation that the diffusion of radon and thoron from the lunar surface provides a mechanism for production of a radioactive surface layer on the moon. The work is based on what is known about the terrestrial rates of convection and diffusion of these gases, which are generated through radioactive decay of U^{238} and Th^{232}. In the solution of the diffusion equations, a negligible concentration of radon at the lunar surface as compared with that at depth has been assumed; this assumption is consistent with a uniform atmosphere extending to an altitude of 10 km. The significance of lunar alpha activity is discussed, and it is expected that a measurement of such activity will indicate if the moon is differentiated. It is concluded that on the moon an astronaut with an exposed suit area of 1 m^2 will acquire a surface alpha activity of about 1 μc. Thus, possible contamination of the interior of a spacecraft or of returned samples should be considered. M. L.

A66-32958 #

THE FIRST AUTOMATIC STATION TO LAND ON THE MOON.

COSPAR Information Bulletin no. 31, Apr. 1966, p. 36-47.

Description of the construction and flight of the Soviet space vehicle Luna 9, the first instrument to transmit scientific information from the surface of the moon. The four flight stages of Luna 9 are discussed and diagramed, and several of the images of the lunar surface which were transmitted to earth are reproduced. B. B.

A66-33006

OBSERVABILITY OF INDIGENOUS ORGANIC MATTER ON THE MOON.

J. J. Gilvarry (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.).

Icarus, vol. 5, May 1966, p. 228-236. 39 refs.

The theories of Gilvarry and Sagan implying the presence of indigenous organic matter on the moon are reviewed briefly, for comparison. The former postulates the presence in the lunar maria of organic remains derived from a pristine biota in a hydrosphere formed by exudation from the moon's interior and lasting several billion years. The latter assumes the presence of organic matter on the lunar highlands, now covered by meteoritic infall, formed by the action of solar ultraviolet light and other agencies on a reducing protoatmosphere lasting significantly less than a billion years. However, the fact that meteoritic infall on a moon without an atmosphere causes a net loss of mass from that body is determinative for observability in the Surveyor and Apollo missions of the organic vestiges postulated in the two theories. On Gilvarry's model, a loss of mass from the lunar surface of at least 7 meters in depth is found for the effects of meteoritic impact and sputtering action (by the particles of the solar wind and flares) over the period of several billion years since the atmosphere and hydrosphere vanished. As the organic remains producing the dark color of the maria are assumed distributed throughout the bulk of the sediments in the maria floors, the coloration cannot be destroyed by superficial loss of mass by meteoritic impact. It follows that future lunar explorers should find organic fossils below the depth of roughly 3 to 5 meters fixed by the charring action of the most penetrating radiation, the cosmic rays. Self-consistently on Sagan's theory, no over all gain of mass by meteoritic action on the moon could occur, which is at variance with his conclusion of a depth of burial of organic vestiges amounting to some tens of meters. The actual loss of mass on the model after the lunar atmosphere vanished would be at least 10 meters in depth, and hence the organic remains postulated as superficially distributed at a remote time would be completely unobservable at present. (Author)

A66-33010

SOME RESULTS OF RESEARCH ON LUNAR LUMINESCENCE.

A. Righini, Jr. (Astronomical Observatory, Padua, Italy) and M. Rigutti (Consiglio Nazionale delle Ricerche, Centro di Studio per l'Astrofisica, Osservatorio Astrofisico, Arcetri, Italy).

Icarus, vol. 5, May 1966, p. 258-265. 5 refs.

Research on lunar luminescence has been done with a technique similar to that illustrated by Kopal and Rackham in the period from Nov. 1964 to Jan. 1965. No luminescence phenomena have been observed, but the analysis of the observations has pointed out that some precautions must be taken in order to obtain reliable photographic observations. Also pointed out is the necessity of systematic observations during a long period of time, possibly a solar cycle, in order to clarify the characteristics of the suspected relation between solar activity and lunar luminescence. (Author)

A66-33019

ON THE HARMONIC ANALYSIS OF ABSOLUTE LUNAR ELEVATIONS.

Donald H. Eckhardt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).

Icarus, vol. 5, May 1966, p. 313-316. 12 refs.

Discussion of methods used in the determination of the harmonics of absolute lunar elevations. Analyses are made showing that stability is achieved only with the assumption of symmetry and the introduction of limb elevations; it is shown that this is apparent through the fourth degree. It is important, therefore, to consider systematic differences between the two sets of elevations. The probable existence of these differences leads to the conclusion that no matter how imposing the mathematics may be, available absolute lunar elevation data are insufficient to allow reliable spherical harmonic analysis of the geometric figure of the moon. M. M.

A66-33235 #
CONVECTION IN THE MOON - A BOUNDARY CONDITION.
G. Fielder (London, University, Observatory, Mill Hill, Middx., England).
Geophysical Journal, vol. 10, Jan. 1966, p. 437-443. 8 refs.
Research supported by the Science Research Council.
Recent British and United States maps of a system of structural lineaments on the moon have been compared. The two principal families of lineaments trend SW-NE and SE-NW in the center of the moon's disk, but the surface grid so formed loses its orthogonal character as the limb is approached along the prime meridian or equator. These two great circles are found to be lines of symmetry of the grid system in the orthographic plane. The symmetry defines an extraordinary boundary condition for any theory of convection within the moon; yet the condition appears to be fulfilled by the theory of second-order convection cells proposed for another reason by Runcorn. (Author)

A66-33625
EVIDENCE FOR THE VOLCANIC ORIGIN OF LUNAR AND MARTIAN CRATERS.
John F. Simpson (Goodyear Aerospace Corp.; Akron, University, Akron, Ohio).
Earth and Planetary Science Letters, vol. 1, May 1966, p. 130, 131.
Study of the relationship existing in the percentage distribution of crater diameters on the moon and Mars, which appears remarkably similar when normalized to uniform gravity. The percentage distribution of craters on both the moon and Mars is plotted. It may be seen that the form of the curves is similar and that the average value of the lunar crater diameters is approximately 3.15 times the Martian crater diameters at any percentage value. This relationship is noted to be consistent with a volcanic origin for the majority of lunar and Martian craters. M. F.

A66-33626
ADDITIONAL EVIDENCE FOR THE VOLCANIC ORIGIN OF LUNAR AND MARTIAN CRATERS.
John F. Simpson (Goodyear Aerospace Corp.; Akron, University, Akron, Ohio).
Earth and Planetary Science Letters, vol. 1, May 1966, p. 132-134.
Complete results of a study showing the similarity in frequency distribution of lunar and Martian craters with terrestrial volcanic craters, and the dissimilarity of these groups with terrestrial meteoric craters. Subjects discussed include Mars and lunar crater diameters, terrestrial volcanic and meteoritic crater diameters, the normalization of extraterrestrial craters to the earth's gravity, and surface density effects. It is concluded that the frequency distributions of Martian and lunar craters are very similar to terrestrial volcanic craters, when normalized for surface gravity and density. Furthermore, a distinct dissimilarity exists between these frequency distributions and those of terrestrial meteoritic craters. Therefore, this represents a strong implication for a volcanic origin of the bulk of Martian and lunar craters. M. F.

A66-34013 #
RAPID REMOTE SENSING BY A "SPECTRUM MATCHING" TECHNIQUE. I - DESCRIPTION AND DISCUSSION OF THE METHOD.
Graham R. Hunt (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).
Journal of Geophysical Research, vol. 71, June 15, 1966, p. 2919-2930. 6 refs.
A method of rapid remote sensing is described which is applicable for obtaining information about the compositions of materials from both terrestrial and extraterrestrial sources. It is a method of infrared spectrum matching, in which the emission spectrum from the source is instrumentally compared with the reflection spectra of a set of polished samples of different compositions. The effects of other variables, such as temperature and surface condition, are explored, and the effect of an intervening attenuator is considered. It is found that despite the presence of other variables identification of compositional differences between targets can be made. (Author)

A66-34099 #
SOME ENERGETICAL CALCULATIONS REGARDING THE RECENT VOLCANIC PHENOMENA OF THE MOON.
G. Deák, K. Erdősi, M. Füredi, P. Hédervári, and I. Sugár.
Gerlands Beiträge zur Geophysik, vol. 75, no. 2, 1966, p. 122-128. 6 refs.
Discussion of two circular and one elliptical reddish spots which recently formed in the area of the crater Aristarchus. Based on the assumption of the volcanic origin of these spots, the thermal energy is calculated that was liberated from the interior of the moon during the development of the spots. The calculations make use of hypothetical data on the type and thickness of the material of the spots. The results of the calculations are seen to support the assumption of the volcanic origin of the spots.

A66-34487
INFRARED SPECTROPHOTOMETRY OF THE MOON AND THE GALILEAN SATELLITES OF JUPITER.
V. I. Moroz (Moskovskii Gosudarstvennyi Universitet, Gosudarstvennyi Astronomicheskii Institut, Moscow, USSR).
(Astronomicheskii Zhurnal, vol. 42, Nov.-Dec. 1965, p. 1287-1295.)
Soviet Astronomy, vol. 9, May-June 1966, p. 999-1006. 20 refs.
Translation.
[For abstract see issue 08, page 1298, Accession no. A66-19458]

A66-34573 #
TESTS FOR RANDOMNESS IN THE DISTRIBUTION OF LUNAR CRATERS.
G. Fielder (London, University, Observatory, Mill Hill, Middx., England).
Royal Astronomical Society, Monthly Notices, vol. 132, no. 4, 1966, p. 413-422. 11 refs.
Analysis of the distribution of lunar craters. Two different methods are used to avoid mixing different number densities of craters in adjacent lunar regions. The results indicate clustering of significantly greater degree than predicted by the impact hypothesis. It is concluded that a significant proportion of the craters is of internal origin. R.A.F.

A66-34655
TRANFORMATIONS OF THE LUNAR COORDINATES AND ORBITAL PARAMETERS.
W. J. Eckert, M. J. Walker, and D. Eckert (International Business Machines Corp., Watson Laboratory, New York, N.Y.).
Astronomical Journal, vol. 71, June 1966, p. 314-332. 10 refs.
Use of Brown's lunar theory as a basis from which to discuss observed lunar motion and to examine critically new and more precise theoretical developments. This theory is of high quality and has long been accepted as a standard of comparison. In the modification of Brown's basic solution to facilitate comparison with observations, the full precision of the solution was not preserved since this was not then considered necessary. An attempt is made to make the full accuracy of Brown's solution available for comparison with observations, and to increase the precision of the relations between the computed coordinates and the parameters on which they are based. The precision of the solar terms in sine parallax is improved by more than an order of magnitude. F.R.L.

A66-34656
AN IMPROVED THEORETICAL LUNAR PHOTOMETRIC FUNCTION.
Bruce Hapke (Cornell-Sydney University Astronomy Center, Ithaca, N.Y.).
Astronomical Journal, vol. 71, June 1966, p. 333-339. 17 refs.
Grant No. NsG-382.
Improvement of a previously proposed theoretical photometric function for the lunar surface, which successfully predicted variations of brightness for areas between selenographic longitudes

of ±60°, so that it better agrees with observations in the limb regions. The modification consists of wrinkling the porous, open surface of the previous model into a series of steep-sided depressions. The primary requirement is that the surface must be densely covered (~90%) with features, the walls of which make steep angles (≳ 45°) with the local horizontal, and that these walls must be visible even at glancing angles. This model is consistent with radar-deflection data which indicate that the moon is rough on a subcentimeter scale. These roughness features are probably primary and secondary meteorite craters and ejecta debris which saturate the lunar surface on a small scale. F. R. L.

A66-35048
ISOPHOTES OF THE ARISTARCHUS REGION ON THE MOON.
C. Titulaer (Utrecht, Rijksuniversiteit, Sterrewacht Sonnenborgh, Utrecht, Netherlands).
Astronomical Institutes of the Netherlands, Bulletin, vol. 18, Jan. 1966, p. 167-169. 5 refs.
Isophotometric measurements have been made on plates, taken during the total eclipse of the moon on Dec. 19, 1964. This paper gives the profiles of the isophotes and their relative intensities. It was not possible to determine the variation of intensity with time. The plates were obtained with the Utrecht refractor and measured with the Amsterdam isophotometer. (Author)

A66-35245 #
THE LUNAR CRATER CARAMUEL.
D. A. Allen.
British Astronomical Association, Journal, vol. 76, June 1966, p. 248-255.
Description of the geographic and topographic features of the lunar crater Caramuel, located at latitude 17.2 and longitude 88.5, with a diameter of 28-1/2 miles. It lies on a convex mound about 60 mi in diameter and 12,000 ft high. Difficulties in the course of past observations of the crater (which is only favorably visible on one night of the year) are described. Tables are presented which list the position and diameter of Caramuel as quoted by various authors and the height in feet of its features based on 1965 photographs. D. P. F.

A66-35284 #
LUNAR CRATER THEORY [K TEORII LUNNYKH KRATEROV].
A. K. Mukhamedzhanov and K. P. Staniukovich.
Kosmicheskie Issledovaniia, vol. 4, May-June 1966, p. 408-413. 12 refs. In Russian.
Discussion of the peculiarities of the dispersion of matter resulting from meteorite impact on the lunar surface. It is shown that lunar substance dislodged by meteorite impact can produce a dislodgement of matter when falling back onto the surface. Each subsequent dislodgement effect, however, will be much weaker than the previous one. It is suggested that the concentric nature of crater structure can be explained by these effects. V. P.

A66-35437
THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965.
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess (NASA, Goddard Space Flight Center, Laboratory for Theoretical Studies, Greenbelt, Md.), D. H. Menzel (Harvard University, Harvard College Observatory, Cambridge, Mass.), and J. A. O'Keefe (NASA, Goddard Space Flight Center, Greenbelt, Md.).
Baltimore, Md., Johns Hopkins Press, 1966. 320 p. $13.50.

CONTENTS:

A66-35438
OBSERVATIONS ON THE RANGER PHOTOGRAPHS.
H. C. Urey (California, University, La Jolla, Calif.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 3-21.

Evaluation of the Ranger 7, 8, and 9 and terrestrial photographs of the moon's surface. The thermal history, chemical composition, and nature of the interior of the moon are discussed, and craters, ray areas, dimples, wrinkles, clifflike structures, presumed lava flows, and various maria are considered. B.B.

A66-35439
PRELIMINARY ANALYSIS OF THE FINE STRUCTURE OF THE LUNAR SURFACE IN MARE COGNITUM.
Eugene M. Shoemaker (U.S. Geological Survey, Flagstaff, Ariz.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 23-77. 33 refs.
Review of the basic new facts established by the Ranger 7 satellite photographs, formulation of a model of the fine structure of the lunar topography in Mare Cognitum, and the development of hypotheses concerning the surface processes. The small topographic features revealed by the Ranger 7 photographs of Mare Cognitum are almost all craters. Primary and secondary craters are defined on the basis of morphology and distribution. One of the most striking features revealed by the Ranger 7 photographs is the rarity of small positive relief features other than crater rims. It is found that cratering is the dominant process responsible for the small relief features of Mare Cognitum. In considering a preliminary model for the fine structure of the Mare Cognitum it is found that the scattering lunar surface is covered with very fine, nearly opaque grains. D.P.F.

A66-35440
THE SURFACE OF THE MOON.
E. A. Whitaker (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 79-98.
Summary of conclusions reached by the Lunar and Planetary Laboratory of the University of Arizona concerning the lunar surface. Many of the photos from which the conclusions were drawn are given. R.A.F.

A66-35441
THE SURFACE STRUCTURE OF THE MOON.
Gerard P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 99-105. 7 refs.
Summary of some of the scientific results from the Ranger 7, 8, and 9 missions. The texture of the maria, crater rays, crater classification, the mare ridges, rilles, and lineaments, and the bearing strength of a mare floor are discussed. R.A.F.

A66-35442
THE MOON'S SURFACE.
T. Gold (Cornell University, Center for Radiophysics and Space Research, Newman Laboratory of Nuclear Studies, Ithaca, N.Y.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 107-121.
Consideration of the surface characteristics of the moon. Radar-scattering, optical-scattering, thermal, photographic, and other data are analyzed. R.A.F.

A66-35443
INTERPRETING RANGER PHOTOGRAPHS FROM IMPACT CRATERING STUDIES.
Donald E. Gault, William L. Quaide, and Verne R. Oberbeck (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 125-140.
Results from impact cratering experiments and field studies of missile impact craters. The studies show that projectiles with velocities typical of secondary bodies on the moon produce craters with geometries which are sensitive to target strength and angle of impact. Interpretation of Ranger photographs in the light of these findings indicates that the lunar surface consists of materials having low cohesive strength, the thickness probably measuring in meters or tens of meters. R.A.F.

A66-35444
OPTICAL PROPERTIES OF THE MOON'S SURFACE.
B. W. Hapke (Cornell University, Center for Radiophysics and Space Research, Ithaca, N.Y.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 141-154.
NASA-sponsored research.
Analysis of the outermost millimeter or so of the lunar surface, on the base of optical data on the moon's surface and related laboratory studies. The optical evidence is considered to give very strong indications that the surface of the moon is covered with a layer of fine dust, the thickness of the layer being unknown. R.A.F.

A66-35445
THE APPLICATION OF POLARIZED LIGHT FOR THE STUDY OF THE SURFACE OF THE MOON.
A. Dollfus (Paris, Observatoire, Section d'Astrophysique, Meudon, Seine-et-Oise, France).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 155-172.

Analysis of data on the polarization of light reflected from the lunar surface. It is concluded that the surface of the moon is completely covered, in all areas, by a layer of small, uncompacted, highly absorbing dust particles. The polarization techniques are not precise enough to establish the exact composition of the dust.
R.A.F.

A66-35446
LUMINESCENCE OF THE MOON AND SOLAR ACTIVITY.
Zdeněk Kopal (Manchester, University, Dept. of Astronomy, Manchester, England).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 173-183. 29 refs.
Review of observations of transient luminous phenomena on the lunar surface, and discussion of their quantitative aspects. It is pointed out that several conspicuous instances of such phenomena followed transient disturbances on the sun by intervals of from several hours to a few days. This is seen to indicate that the sources of excitation are probably corpuscular, rather than electromagnetic, radiation.
R.A.F.

A66-35448
RECENT DISCOVERY OF HOT SPOTS ON THE LUNAR SURFACE - A BRIEF REPORT OF INFRARED MEASUREMENTS ON THE ECLIPSED MOON.
R. W. Shorthill and J. M. Saari (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 215-228.
Results from measurements of lunar thermal radiation in the 10- to 12-μ region, taken during the total lunar eclipse of Dec. 19, 1964. Some 400 anomalous hot spots are identified in the data. No explanation is advanced for these anomalies.
R.A.F.

A66-35449
REVIEW OF RADAR OBSERVATIONS OF THE MOON.
T. Hagfors (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 229-239; Discussion, H. C. Urey (California, University, La Jolla, Calif.), p. 239. 17 refs.
The methods available for the study of the moon by means of radar are briefly reviewed, a discussion is given of the information which can be derived from radar studies about the nature of the lunar surface, and results of radar observations of the moon are presented. From these results, it is concluded that the lunar surface is covered by a material having an effective dielectric constant of 2.6 and that the surface undulations on the moon have a mean slope of 11-12° on the scale of about 1 m. The enhanced reflectivity of young rayed craters has been interpreted as both a higher intrinsic reflectivity and a higher degree of roughness in these features.
(Author)

A66-35450
TERRESTRIAL CALDERAS, ASSOCIATED PYROCLASTIC DEPOSITS, AND POSSIBLE LUNAR APPLICATIONS.
Robert L. Smith (U.S. Geological Survey, Washington, D.C.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 241-257; Discussion, W. C. Cameron and J. Green, p. 257.
Study of terrestrial calderas defined as basins of subsidence larger than volcanic craters and discussion of possible lunar applications. Three major caldera types are briefly discussed: (1) Kilauean calderas, (2) Krakatoan calderas, and (3) resurgent cauldrons. Examples of each type of calderas are given together with illustrations. It is noted that the Krakatoan type calderas, formed by subsidence of the tops of large andesitic volcanoes, are the most common type among the active volcanoes on the earth, Kilauean calderas are primarily caused by subsidence without surface volcanism and resurgent cauldrons are typified by a central structural mountain mass. It is pointed out that many of the lunar craters of the large type appear to have one feature in common that is incompatible with all terrestrial calderas - i.e., the hilly, hummocky, and chaotic topography that forms their rims and immediate surroundings.
M.F.

A66-35451
LUNAR ASH FLOWS.
John A. O'Keefe (NASA, Goddard Space Flight Center, Greenbelt, Md.).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 259-264; Discussion, F. L. Whipple, M. Dubin, and Z. Kopal (Manchester, University, Dept. of Astronomy, Manchester, England), p. 264-266.
Explanation of the softened appearance seen on some of the lunar craters by the presence of lunar ash flows. It is a fact that large craters, craters above a certain size, are softened in some way or another. As an explanation, the author proposes that this softening is the result of the deposit of a blanket of ash over the moon's surface. The problem of why this ash flow leads to shallow craters is examined. A distinction is made between the soft, large craters and the hard, small craters. An alternative explanation for this softening of the craters is erosion. But it is the author's contention that erosion is not the true cause. The origin of the energy for lunar volcanism is discussed and the explanation of the softening by erosion is upheld by other scientists in a discussion.
M.F.

A66-35452
THERMAL HISTORY OF THE MOON AND THE DEVELOPMENT OF ITS SURFACE.
B. J. Levin (Academy of Sciences, Institute of Physics of the Earth, Moscow, USSR).
IN: THE NATURE OF THE LUNAR SURFACE; PROCEEDINGS OF THE 1965 INTERNATIONAL ASTRONOMICAL UNION/NASA SYMPOSIUM, GODDARD SPACE FLIGHT CENTER, GREENBELT, MD., APRIL 15, 16, 1965. [A66-35437 19-30]
Symposium sponsored by the International Astronomical Union and NASA.
Edited by W. N. Hess, D. H. Menzel, and J. A. O'Keefe.
Baltimore, Md., Johns Hopkins Press, 1966, p. 267-271; Discussion, p. 271-273. 15 refs.
Discussion of the question of whether the idea of nearly simultaneous formation of the lunar maria agrees with the calculations of the thermal history of the lunar interior. Calculations of the

thermal history of the moon lead to the conclusion that a period favorable for lava effusions occurred 2.5 to 3.0 aeons (billion years) ago (depending on the content of radioactive elements in the moon). At that time spontaneous breakthrough and effusions of lava were probably possible. A second question which arises is whether the thermal history of the moon is compatible with the history of the bombardment of its surface. The author's positive answer to this question is based on the idea of the common origin of the moon and the earth. The hypothetical melting of the interior of the moon is discussed. M.F.

A66-35793 #
AN HYPOTHESIS CONCERNING THE EVOLUTION OF THE LUNAR SURFACE.
D. M. Miller.
Current Science, vol. 35, May 5, 1966, p. 225-228. 9 refs.

Statement and application of a hypothesis concerning the evolution of the lunar surface. It is contended that at the time the lunar surface solidified into a crust the amount of interplanetary material was such that the subsequent infall would have covered the bedrock with a layer of dust the present average thickness of which is believed to be of the order of a kilometer. The various features visible on the moon's surface are attributed to distortions of this layer caused by collisions of planetesimals and other large bodies with it. This process is illustrated by a number of examples. A.B.K.

A66-35901
ACCURACY IN THE DETERMINATION OF LUNAR TRANSPONDER LOCATION FROM POSTARRIVAL TRACKING.
T. H. Elconin (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
(American Institute of Aeronautics and Astronautics, and Institute of Navigation, Astrodynamics Specialist Conference, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 16, 17, 1965, Paper 65-694.)
IN: METHODS IN ASTRODYNAMICS AND CELESTIAL MECHANICS. Edited by R. L. Duncombe and V. G. Szebehely.
New York, Academic Press, Inc., 1966, p. 297-323.
[For abstract see issue 22, page 3345, Accession no. A65-33705]

A66-36213 #
MOON CHARTER.
János Kiss.
IN: COLLOQUIUM ON THE LAW OF OUTER SPACE, 8TH, ATHENS, GREECE, SEPTEMBER 14, 15, 1965, PROCEEDINGS. [A66-36201 19-34]
Colloquium sponsored by the International Institute of Space Law of the International Astronautical Federation.
Edited by A. G. Haley and M. D. Schwartz.
South Hackensack, N.J., Fred B. Rothman and Co., 1966, p. 234-238.

Brief comparison of the resolutions of the General Assembly of the UN, the International Law Association, and the Institute of International Law concerning the declaration of the fundamental international legal status of celestial bodies, especially the moon. Twelve general principles are recommended for a draft text of a moon charter. M.L.

A66-36312
THE CONCEPT OF VOLCANO-TECTONIC UNDULATION IN SELENOLOGY.
G. J. H. McCall (Western Australia, University, Dept. of Geology, Nedlands, Australia).
IN: ADVANCES IN SPACE SCIENCE AND TECHNOLOGY. VOLUME 8.
Edited by F. I. Ordway, III.
New York, Academic Press, Inc., 1966, p. 1-64. 81 refs.

Proposed mechanism for selenological processes which assumes that the lunar surface is anorogenically molded, and that the strange pattern of craters and lineaments stems from intermittent reactivation of numerous linear anorogenic zones which form a close reticulation all over the lunar surface. Arguments are adduced to refute the concept of the formation of lunar craters by meteoric impact. Although ample use is made of terrestrial analogy, it is not considered that the lunar vulcanism is identical, or even similar to that occurring on the earth. Based on geological considerations, a case is presented for supposing that lunar vulcanism involves much gas emission and only fumarolic encrustation to produce solid rocks (except for possible minor molten effusions of an unknown nature). This may have produced a volcanogenic envelope, unlike the terrestrial crust. F.R.L.

A66-37019
A SPECTROPHOTOMETRIC STUDY OF THE LUNAR SURFACE.
N. N. Petrova (Akademiia Nauk SSSR, Glavnaia Astronomicheskaia Observatoriia, Pulkovo, USSR).
(Astronomicheskii Zhurnal, vol. 43, Jan.-Feb. 1966, p. 162-171.)
Soviet Astronomy, vol. 10, July-Aug. 1966, p. 128-135. 27 refs. Translation.
[For abstract see issue 12, page 1945, Accession no. A66-23506]

A66-37151 #
THERMAL HISTORY OF THE MOON [K VOPROSU O TEPLOVOI ISTORII LUNY].
O. I. Ornatskaia and Ia. I. Al'ber (Gor'kovskii Gosudarstvennyi Universitet, Nauchno-Issledovatel'skii Radiofizicheskii Institut, Gorki, USSR).
(Soveshchanie po Planetnoi Kosmogonii, Moscow, USSR, June 21, 1965.)
Radiofizika, vol. 9, no. 3, 1966, p. 615-617. 9 refs. In Russian.

Solution of the equation of thermal conductivity for four combinations of concentration of radioactive elements in the lunar crust, as proposed by Krotikov, Troitskii and others. The thickness of the solid lunar crust is estimated on the basis of the results. V.Z.

A66-37260 #
HEAT TRANSFER IN LUNAR ROCK.
P. E. Clegg, J. A. Bastin, and A. E. Gear (London, University, Queen Mary College, Dept. of Physics, London, England).
Royal Astronomical Society, Monthly Notices, vol. 133, no. 1, 1966, p. 63-66. 6 refs.

It is suggested that radiative transfer may play an important part in the mechanism of heat flow in the lunar surface and a simple treatment of this process is given. Rough estimates are made of the magnitude of the contribution of radiative transfer, and it is found that this process could account for a considerable fraction and perhaps almost all the heat flow deduced from infrared measurements. Furthermore such a mechanism is of the right form to remove certain discrepancies which have been noted in infrared and microwave data. (Author)

A66-38025
SIMULATED BASALT AND GRANITE MAGMA UPWELLED IN VACUUM.
Walter I. Dobar (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
Icarus, vol. 5, July 1966, p. 399-405.

The upwelling and solidification of a simulated basalt and granite magma in vacuum has produced a porous material not found in nature. The photometric curves of the upwelled samples show excellent correlation with the photometric curves of the lunar surface. The visible colors associated with the simulated magma during vacuum upwelling matches the visual observations of the color phenomena observed on the lunar surface in Oct. and Nov. 1964. The bearing strength of the vacuum-formed materials ranges from 1.5 to 6.5 tons/ft^2. (Author)

A66-38026
EARLY LUNAR CRATERING.
William K. Hartmann (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
Icarus, vol. 5, July 1966, p. 406-418. 24 refs.
During the first seventh of lunar history, the cratering rate on the moon averaged roughly two hundred times the average postmare rate. The peak rate may have been much higher. Crater densities are thus not proportional to age. The large, circular mare basins fit the diameter distribution of the "continental" craters and are thus identified with the premare cratering. This cratering is assumed to be due to a high early bombardment rate by objects of uncertain origin. Mars does not show early intense cratering. The objects were probably fragmented by collisions to a substantial degree and were probably not the planetesimals from which the moon and planets accreted. In this case, the true planetesimals from which the moon accreted were probably smaller than 10^{15} g, and may represent an intermediate stage in planetesimal growth. Of six hypothetical origins considered for the objects, a circumterrestrial swarm, probably related to the origin of the moon, appears the most likely. Observational tests for the hypotheses are listed. (Author)

A66-38030
SURVIVAL TIME OF LUNAR SURFACE IRREGULARITIES AND VISCOSITY DISTRIBUTION WITHIN THE MOON.
Yasuo Shimazu (Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 5, July 1966, p. 455-458. 7 refs.
Examination of the inequalities in the distribution of continents and maria on the lunar surface as a means to understanding the internal state of the moon. Various explanations for the abnormal amount of moment of inertia are described. The viscosity distribution within the moon is analyzed using the Navier-Stokes and the continuity equations. Only large craters are considered in the analysis; the results are given based on the nonuniform deformation of a viscous sphere as a model. A model consisting of a floating shell is the basis for an alternate set of calculations. D. P. F.

A66-38052
ENERGY BALANCE ON THE LUNAR SURFACE.
Neil Ashby (Colorado, University, Dept. of Physics and Astrophysics, Boulder, Colo.).
Astronomical Society of the Pacific, Publications, vol. 78, June 1966, p. 254, 255. 8 refs.
NASA-supported research.
Determination of the reflected energy reflected from the moon's surface. The value 0.106 ± 0.01 cal cm^{-2} min^{-1} is assigned to the average reflected energy. Since about 0.008 cal cm^{-2} min^{-1} is conducted into the surface, about 1.88 ± 0.02 cal cm^{-2} min^{-1} should be radiated. B. B.

A66-38059
ORIGIN OF LUNAR TEKTITES [DIE HERKUNFT DER TEKTITE VOM MOND].
Ernst Adams (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für angewandte Mathematik und Mechanik, Freiburg im Breisgau, West Germany).
(Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Symposion Erforschung des Mondes und des interplanetaren Raumes, Munich, West Germany, Apr. 22, 1966, Vortrag.)
Raumfahrtforschung, vol. 10, July-Sept. 1966, p. 105-109. 39 refs.
In German.
Review of available data on the origin of tektites. It is considered unlikely that tektites are of terrestrial origin. The moon is considered the most likely extraterrestrial source for tektites, so they may thus provide a source of information on the moon's history and surface. R.A.F.

A66-38506
IMPLICATIONS OF HIGH VACUUM ON THE CHARACTERISTICS OF THE LUNAR SURFACE.
Peter E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.).
(American Vacuum Society, National Vacuum Symposium, 12th, New York, N.Y., Sept. 28-Oct. 1, 1965, Paper.)
Journal of Vacuum Science and Technology, vol. 3, July-Aug. 1966, p. 181-186. 58 refs.
The pressure on the lunar surface, which may be no higher than 10^{-13} terrestrial atmospheres, has already been shown to have an important effect on the behavior of postulated lunar surface materials. The observational evidence on the nature of the lunar atmosphere is summarized and the implications of the low pressure on lunar surface structural and physical properties are discussed. Lunar environmental effects including micrometeoroid impact and solar radiation are shown to be contributing to the surface characteristics. The effects of low pressures on the vesiculation of lava are used to illustrate structural features which may be present on the lunar surface. Consolidation phenomena, which are expected to produce adhesion of particles on the lunar surface, and the roles of chemical bonds and van der Waals and electrostatic forces are discussed. The effects of the high vacuum on heat-transfer phenomena on the surface are examined and the required characteristics of postulated materials, ranging from a lightweight interconnected structure to a vesicular low-density foam, are listed. The restraints imposed on lunar exploration by the absence of the atmosphere and the expected contamination caused by lunar probes and future lunar-landing vehicles are considered. (Author)

A66-38637
THE LINEAR NETWORK OF LUNAR SURFACE FEATURES.
J. van Diggelen (Utrecht, Rijksuniversiteit, Sterrewacht Sonnenborgh, Utrecht, Netherlands).
Astronomical Institutes of the Netherlands, Bulletin, vol. 18, July 1966, p. 311-322. 23 refs.
This investigation deals with a statistical method for determining the preferential directions shown by lunar surface formations, known as the lunar grid system. This system is defined as the entire collection of linear formations revealed by mountains and ridges on the lunar continents, and also by the walls of polygonal craters. Objects belonging to the grid have been counted on some plates of the Photographic Lunar Atlas and their normalized distribution over the different sectors has been found. The distribution curve was corrected for curvature effects. The real distribution has been determined by subtracting a theoretical random distribution obtained by assuming that the visibility of these objects is proportional to the area of their shadows and by assuming a theoretical distribution of the slopes of the objects in accordance with the mean radar slope. A strong system radially orientated with respect to Mare Imbrium has been found in some lunar regions. Nearly all the systems mentioned by Fielder (1963) could be confirmed by our statistical method. A comparison of the results is tabulated. (Author)

A66-38822
THE FIGURE AND GRAVITY FIELD OF THE MOON.
C. L. Goudas (Boeing Co., Scientific Research Laboratories, Mathematics Research Laboratory, Seattle, Wash.).
IN: ADVANCES IN ASTRONOMY AND ASTROPHYSICS. VOLUME 4. Edited by Zdeněk Kopal.
New York, Academic Press, Inc., 1966, p. 27-151. 62 refs.
Study of the possibilities of deriving reliable models of the figure, density distribution, and gravity field of the moon on the basis of data obtainable through earth-bound telescopes. It is said that much of this work, with small alteration, can be adapted for use with spaceborne observations. Geometric and dynamic properties of the moon are studied, and conclusions are drawn regarding its figure and gravity field. B.B.

A66-39895
THE ON-SITE MANUFACTURE OF PROPELLANT OXYGEN FROM LUNAR RESOURCES.

Sanders D. Rosenberg, Gerald A. Guter, and Frederick E. Miller (Aerojet-General Corp., Azusa, Calif.).
(American Institute of Chemical Engineers, Annual Meeting, 57th, Symposium on Chemical Processing in Extraterrestrial Environments, Boston, Mass., Dec. 6-10, 1964, Preprint 46c.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 228-234.
[For abstract see issue 04, page 518, Accession no. A65-13203]

A66-39897
WATER AND CHEMICAL RECOVERY IN A LUNAR ENVIRONMENT.
R. N. Rickles (Dorr-Oliver, Inc., Stanford, Conn.).
(American Institute of Chemical Engineers, Annual Meeting, 57th, Symposium on Chemical Processing in Extraterrestrial Environments, Boston, Mass., Dec. 6-10, 1964, Preprint 46b.)
Chemical Engineering Progress, Symposium Series, no. 61, 1966, p. 241-246. 14 refs.
[For abstract see issue 04, page 518, Accession no. A65-13202]

A66-40017
LUNA 9 PHOTOGRAPHS - EVIDENCE FOR A FRAGMENTAL SURFACE LAYER.
Donald E. Gault, William L. Quaide, Verne R. Oberbeck (NASA, Ames Research Center, Space Sciences Div., Moffett Field, Calif.), and Henry J. Moore (U.S. Geological Survey, Menlo Park, Calif.).
Science, vol. 153, Aug. 26, 1966, p. 985-988. 13 refs.
Evaluation of the photographs of the lunar surface taken by Luna 9, which are considered to indicate that it consists of a non-cohesive to weakly cohesive, poorly sorted fragmental material of unknown source, with the bulk of the fragments having sizes less than 1 cm and probably less than a few millimeters. The minimum depth of this fragmental layer is approximately 20 cm, but it may be much deeper. Because of the movement of the spacecraft, it was possible to view the photographs stereoscopically. Good stereopsis was obtained for about 100° of the panoramic scan. The views reveal an undulating surface that is littered with rocks and pocked with shallow depressions. Some laboratory studies of cratering in various materials are cited in support of the conclusions. F. R. L.

A66-40210 #
THERMAL SIMULATION OF THE LUNAR SURFACE.
Richard D. Wood and John N. Wilkinson (Aerospace Controls Corp., Los Angeles, Calif.).
IN: AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS, INSTITUTE OF ENVIRONMENTAL SCIENCES, AND AMERICAN SOCIETY FOR TESTING AND MATERIALS, SPACE SIMULATION CONFERENCE, HOUSTON, TEX., SEPTEMBER 7-9, 1966. TECHNICAL PAPERS. [A66-40204 22-11]
New York, American Institute of Aeronautics and Astronautics, 1966, p. 43-55. 8 refs.
Proposal of preliminary engineering data for the thermal simulation of the lunar surface. A conceptual analytical method which could be used effectively for simulating the lunar surface environment is initiated. To obtain the data points for the parametric curves a computer program was written for the IBM 360 computer. Small increments were taken and extensive data points were plotted. Careful use of these curves should give an error analysis to within about ±1%. The reported results indicate that adequate simulation can be provided using this technique in the design of a Lunar Environmental Simulator. Sufficient theoretical material is presented to analyze any particular spacecraft configuration and to minimize temperature error. M. F.

A66-40398
THE MOON'S SURFACE.
Jack Green (Douglas Aircraft Co., Inc., Advanced Research Laboratory, Huntington Beach, Calif.).
International Science and Technology, Sept. 1966, p. 59-62, 64, 66, 67, 82, 84.
An examination of the controversy whether moon craters are of volcanic or meteoritic origin and of the survival advantages of a volcanic over an impacted terrain in case of lunar landing. It is believed that the moon's macrostructural features such as orientation of ridges, relation of domes and rim structures to craters, the relations of craters to regional and global fracture systems are not the result of chance impact of outside bodies, since they inescapably resemble those seen in volcanic provinces on earth often down to the smallest telescopic details. Of the 40 lunar landscape features studied recently every one can be explained by defluidization and only 12 can be explained by impact (or its erosional effects). The essential character of the moon's surface and its variability will not be determined, however, until samples of lunar material have been brought back to earth and examined. S. Z.

A66-40518
LUNAR SURFACE STRENGTH - IMPLICATIONS OF LUNA 9 LANDING.
L. D. Jaffe and R. F. Scott (California Institute of Technology, Jet Propulsion Laboratory and Div. of Engineering and Applied Sciences, Pasadena, Calif.).
Science, vol. 153, July 22, 1966, p. 407, 408. 12 refs.
The ability of the lunar surface to support statically the Luna 9 capsule indicates that the surface can bear at least 5×10^3 dynes/cm^2 (10^{-1} lb/in.^{2}). Analysis of the landing dynamics, using available data, gives a lower bound of about 1 to 2×10^5 dynes/cm^2, but this estimate may not be conservative because of uncertainties regarding the shock-absorbing system used and the direction of the velocity vector at impact. (Author)

A66-40522
LUNA 9 PICTURES - IMPLICATIONS.
T. Gold and B. W. Hapke (Cornell-Sydney University Astronomy Center, Ithaca, N. Y.).
Science, vol. 153, July 15, 1966, p. 290-293. 6 refs.
Grant No. NsG-382.
Evaluation of evidence from Luna 9 which, it is considered, does not preclude the possibility that the moon may have a surface made up largely of very fine rock particles. Experiments were made with dry commercial cement powder, and surfaces were obtained which, in appearance, closely resembled the lunar surface as photographed at very close range. Attention is drawn to two apparent shifts of the package, which may indicate that the lunar subsurface contains very many cavities which are in a precarious state of equilibrium. F. R. L.

A66-40544
LUNAR BASINS, LUNAR LINEAMENTS, AND THE MOON'S FAR SIDE.
William K. Hartmann (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).
Sky and Telescope, vol. 32, Sept. 1966, p. 128-131.
Discussion of the origin of lunar basins (or thalassoids), the evolution of ancient planetary surfaces, the history of huge concentric structures, and the origin of radial and grid systems of lineaments on the lunar surface. Several photographs taken from earth are compared with photos of the same features taken by the Soviet space probe Zond 3. The word basin is used for the large circular features, which usually show radial and concentric structure and are flooded to a greater or lesser extent by mare material. A plot is included of the number of craters within certain ranges of diameter that occur in a million square kilometers of lunar surface. Detailed examination and discussion of the Mare Orientale is included. Especially of this system, but of these features in general, it is concluded that there exists a strong asymmetry with a tendency for northwest-to-southeast alignment (astronautic directions). In the light of the apparent existence of a similar pattern of surface features on Mars, basic mechanisms are discussed. M. L.

A66-41151
A METHOD FOR TRANSLUNAR RADIO COMMUNICATION.
Winfield W. Salisbury (Harvard University, Harvard College Observatory; Smithsonian Institution, Smithsonian Astrophysical Observatory, Cambridge, Mass.).
Nature, vol. 211, Aug. 27, 1966, p. 950, 951.
Discussion of the possibility of using sublunar surface materials as a propagation medium for translunar communication, on the basis of the special properties which are believed to be likely for the lunar lithosphere. The immediate surface layers have an extremely low thermal conductivity and a very low content of liquid water, as shown by microwave thermal observations. Thus, there is some evidence that the outer layers of the moon contain considerable quantities of material similar to earthly pumice, in that this material has been expanded by gas bubbles during some stage of formation, and/or was formed from meteoric splash dust and thermal cycle spallation products, rewelded on succeeding surfaces by direct solar action. If these conditions persist for an appreciable depth, then a considerable volume of the outer part of the moon is likely to be transparent to radio waves in the range from the lowest frequencies that can be radiated by practical antennas up to frequencies in tens of megacycles per second. M.M.

A66-41209 #
LUNAR DOMES.
W. Leslie Rae.
British Astronomical Association, Journal, vol. 76, Aug. 1966, p. 319-327. 17 refs.
Definition of lunar domes and a historical review of work done in observing and listing them, which culminated in the publication of a catalog containing 113 cases. A criterion for inclusion in the catalog is that the dome must have been visually observed in a clear manner by several observers. The published study leads to the conclusion that they are principally spread widely over the lunar surface, but normally only in the lava areas - e.g., on maria or the floors of lava craters. On the maria they tend to occur near the mare borders rather than in the central areas. Only a small number are associated with rilles. The majority appear to have some association with craters or ringlike structures. The principal tendency is to occur in clusters, where alignments are apparent and in some cases obvious. With the information currently available it is not possible to decide which igneous mechanism is most likely responsible for dome origin. S.Z.

A66-41309
"DUST" ON THE MOON.
Harold C. Urey (California, University, La Jolla, Calif.).
Science, vol. 153, Sept. 16, 1966, p. 1419, 1420. 10 refs.
AEC-supported research.
Observation that Gold's ideas of the surface characteristics of the moon's maria have been misrepresented in many instances by scientists and the press. It is generally assumed that Gold suggested that great depths of fluid dust, which will not support a space vehicle, fill the maria. It is noted that Gold did not imply that the dust layers have low physical strength. Several sources of the mare material are suggested, and some findings of Rangers 7, 8, and 9; Surveyor 1; and Lunas 9 and 10 relating to the moon's surface are considered. B.B.

A66-41410 #
MEASUREMENT OF THE INTENSITY OF PENETRATING RADIATION ON THE SURFACE OF THE MOON [IZMERENIE INTENSIVNOSTI PRONIKAIUSHCHEGO IZLUCHENIIA NA POVERKHNOSTI LUNY].
S. N. Vernov, P. V. Vakulov, E. V. Gorchakov, Iu. I. Logachev, G. P. Liubimov, A. G. Nikolaev, and N. V. Pereslegina (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR).
Akademiia Nauk SSSR, Doklady, vol. 169, Aug. 11, 1966, p. 1044-1047. In Russian.
Discussion of the radiation count obtained by the soft landing of Luna 9 on the moon. The instrument used was an SBM-10 gas-discharge counter. If all the additional radiation recorded by the counter were considered to be due to gamma-radiation from the lunar surface in the Sea of Storms, where Luna 9 landed, the radiation level of the lunar surface would be about 20 times the level on the earth's surface. However, after correction for multiplication of primary cosmic radiation due to the albedo of the moon, doubled by the effect of the flow of particles from the moon due to its magnetic field, the natural radioactivity of the lunar surface is found to be about the same as that of the earth's surface. Therefore cosmic rays will be the major radiation hazard on the moon. W.A.E.

A66-41862
APPARENT CORRELATION BETWEEN THE LUNAR ECLIPSE BRIGHTNESS AND THE SOLAR WIND.
Satoshi Matsushima (Iowa, State University, Dept. of Physics and Astronomy, Iowa City, Iowa).
Nature, vol. 211, Sept. 3, 1966, p. 1027, 1028. 11 refs.
NSF-supported research.
Investigation, based on recent results of space experiments, whether there is any correlation between the brightness of the moon during an eclipse and the interplanetary plasma flux. Data selected for the analysis are from Danjon, Dubois, and Rougier; they consist of a series of three-color photometric observations (centered near λ = 4700, 5300, and 6200 Å) of 18 eclipses between 1932 and 1957. All the measurements were taken at a point 10' inside the umbra-limb with the same "cat-eye" or double-image photometer. The relation between the lunar eclipse brightness and the planetary index, K_p, is graphed, and the eclipse brightness is plotted against the sunspot phase and number. Although calculations are approximate, it is concluded that a correlation is found between the brightness of a lunar eclipse and the interplanetary K_p index which can be interpreted as arising from the effect of lunar luminescence. M.L.

A66-42204
LUNAR DISTURBING FUNCTION.
D. Barton (Cambridge, University, St. John's College, Cambridge, England).
Astronomical Journal, vol. 71, Aug. 1966, p. 438-442.
Description of how, using a new computing technique, it has been possible to expand the lunar disturbing function in terms of the elliptic elements and the mean anomalies to the tenth order of small quantities. It is shown that when the manipulative scheme is used the computer can undertake the entire calculation of the disturbing function beginning from the simplest expression. The result is identical with Delaunay's development to the eighth order. The ninth- and tenth-order terms are new. M.F.

A66-42435
ABUNDANCES OF MAGNETIC SPHERULES IN SILURIAN AND PERMIAN SALT SAMPLES.
Thomas A. Mutch (Brown University, Dept. of Geological Sciences, Providence, R.I.).
Earth and Planetary Science Letters, vol. 1, Sept. 1966, p. 325-329. 13 refs.
USAF-NASA-supported research.
Study designed to compare the abundances of magnetic spherules in 26 ancient salt samples with those reported by Crozier (1966) from recent atmospheric collections. The spherule influx rates are very similar, which suggests that the meteoritic influx has been constant for the three periods of time sampled. This conclusion is in agreement with those of Utech (1963). These findings are believed to provide evidence in support of one of the basic assumptions (Shoemaker, 1964) underlying interpretation of lunar surface history - that meteoritic influx has been constant throughout geologic time, so that the age of a surface can be measured by noting crater density. S.Z.

A66-42722
THE RELATIVE DEPTHS OF LUNAR RING MOUNTAINS AND CRATERS IN MARE NUBIUM.
A. V. Markov (Akademiia Nauk SSSR, Glavnaia Astronomicheskaia Observatoriia, Pulkovo, USSR).
(Akademiia Nauk SSSR, Doklady, vol. 167, Mar. 1, 1966, p. 63, 64.)
Soviet Physics - Doklady, vol. 11, Sept. 1966, p. 187, 188.
Translation.
[For abstract see issue 14, page 2379, Accession no. A66-27182]

A66-43028
IMPLICATIONS OF THE MARINER IV PHOTOGRAPHY OF MARS.
G. J. H. McCall (Western Australia, University, Dept. of Geology, Nedlands, Australia).
Nature, vol. 211, Sept. 24, 1966, p. 1384, 1385. 11 refs.

Criticism of the impact theory of crater formation on the surfaces of the moon and of Mars. It is shown that the various modifications of the impact theory do not explain the anomaly of caldera features in rayed craters. It is believed that lunar and Martian craters do not resemble impact explosion craters, but rather terrestrial volcanotectonic craters - namely, calderas and surface cauldrons. Pronounced scalloping of the wall of a Martian crater observed in a Mariner IV photograph is regarded as evidence of volcanotectonic subsidence. The divergences in the degree of scalloping noted in lunar and Martian craters are said to be more compatible with a hypothesis of endogenous cratering than with the theory of impact cratering. A.B.K.

1967
IAA ENTRIES

A67-10019
FREQUENCY DEPENDENCE AND SURFACE ROUGHNESS.
Adrian K. Fung (Kansas, University, Center for Research, Inc., Lawrence, Kan.).
IEEE, Proceedings, vol. 54, Oct. 1966, p. 1482; Author's Reply, Petr Beckmann (Colorado, University, Dept. of Electrical Engineering, Boulder, Colo.), p. 1482, 1483. 6 refs.
NSF Grants No. GP-2259; No. GK-875.

Examination of disparate approaches by Fung and Beckmann to problems of frequency dependence and surface roughness in lunar studies by radar. Fung considers two approaches. The first - the composite surface approach - assumes that the given surface is a sample function of a random process made up of a sum of many independent random processes. The other approach - the composite correlation approach - uses the fact that in the average return power expression, the only function that characterizes the surface is the correlation function. Fung disagrees with Beckmann on his claim that, unlike the composite correlation method, the composite surface method explains the frequency behavior of the return signal. According to Beckmann, when the rough surface is treated as a composite one, the frequency sampling effect is already included and emerges quite naturally without further assumptions. M.F.

A67-10249
THERMOLUMINESCENCE OF THE MOON.
K. H. Sun and J. L. Gonzalez (Westinghouse Electric Corp., Atomic, Defense and Space Group, Research and Development Center, Research Laboratories, Pittsburgh, Pa.).
Nature, vol. 212, Oct. 1, 1966, p. 23-25. 8 refs.

Experimental measurement of the thermoluminescence of achondrite meteorites on the lunar surface, based on considerations of the rate of temperature rise at the lunar terminator. Previous observations had found the luminescence of enstatite achondrites to have a blue peak and a red peak, hence red and blue optical filters were used separately to investigate the thermoluminescence. Samples were bombarded with 2 Mev electrons at liquid nitrogen temperature in air and allowed to warm up first to room temperature and then to higher temperatures on a hot plate. As the samples warmed, vivid glows of blue and red light emitting and fading from various regions were seen. It is concluded that if the lunar surface is covered with meteorites of the enstatite achondrite type, it is almost certain that red and blue thermoluminescence occurs at the terminator of the moon at dawn. F.R.L.

A67-10319 * #
LUNAR SLOPE ANGLES AND SURFACE ROUGHNESS FROM RANGER PHOTOGRAPHS.
Raoul Choate (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
IN: SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, 4TH, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH., APRIL 12-14, 1966, PROCEEDINGS. [A67-10307 01-13]
Symposium sponsored by the U.S. Navy, Office of Naval Research and the U.S. Air Force, Cambridge Research Laboratories.
Ann Arbor, Mich., University of Michigan, Institute of Science and Technology, Willow Run Laboratories, Infrared Physics Laboratory, 1966, p. 411-432.

Discussion of errors in many published estimates of large slope angles of lunar craters in late P-frame Ranger 7 and Ranger 8 pictures due in part to interpretation of the dark areas in the craters in photographic prints as shadows. It is pointed out that shadows do not exist in late-frame Ranger 7 and Ranger 8 pictures and are barely present in most late P-frame Ranger 9 pictures. Sun angles for Rangers 7 and 8 were 23 and 15°; thus, slopes facing away from the sun and greater than these values cannot be present in the late P-frames. Recent work is discussed which demonstrates that most slopes in Ranger impact areas have small angles. Slope angle, local relief, and surface roughness measurements indicate that, although the impact area of Ranger 8 is somewhat smoother than that of Rangers 7 and 9, topography in all three impact areas probably developed from the same geomorphic processes and is at or near equilibrium. M.M.

A67-10324 #
STUDIES OF THE RADAR PROPERTIES OF ROCKS IN VACUUM AND THE DESIGN OF A SPECIALIZED RADAR FOR MEASURING STRATIFICATION FEATURES OF THE LUNAR AND TERRESTRIAL SURFACE.
D. W. Holdsworth and A. R. Barringer (Barringer Research, Inc., East Natick, Mass.).
IN: SYMPOSIUM ON REMOTE SENSING OF ENVIRONMENT, 4TH, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH., APRIL 12-14, 1966, PROCEEDINGS. [A67-10307 01-13]
Symposium sponsored by the U.S. Navy, Office of Naval Research and the U.S. Air Force, Cambridge Research Laboratories.
Ann Arbor, Mich., University of Michigan, Institute of Science and Technology, Willow Run Laboratories, Infrared Physics Laboratory, 1966, p. 475-487.

Experimental investigation of vhf radar techniques for detecting and mapping subsurface discontinuities such as soil layering, rock interfaces, and discrete bodies such as ore deposits, etc., in lunar and other planetary surfaces. Experiments were carried out using various materials which might be expected to be similar to the lunar rocks and soils. The materials were crushed to various sizes and were measured under extremely dry and vacuum-dried conditions. The loss tangents, dielectric constants and reflectivities were measured. The experiments showed that it is possible to see that a substantial case exists for sounding the lunar surface in the same manner as we are now sounding the polar ice caps. M.M.

A67-10387 *
GEOCENTRIC INITIAL CONDITIONS OF TRAJECTORIES ORIGINATING AT THE MOON'S SURFACE.
Barbara E. Shute (NASA, Goddard Space Flight Center, Special Projects Branch, Greenbelt, Md.).
Astronomical Journal, vol. 71, Sept. 1966, p. 602-609. 6 refs.

A reduced form of the patch conic method has been employed to determine the initial elements of a particle launched or ejected from the moon's surface with any arbitrary starting conditions. The reduction was obtained by considering the selenocentric velocity asymptotes. Explicit and tractable analytic functions have been derived for the geocentric energy, the Jacobi constant, the angular momentum, standard orbital elements, and conditions for moon-to-earth trajectories. Percents of randomly ejected material which initially strike earth, are in retrograde orbits, or go into heliocentric orbits have been obtained. The results are compared with results obtained by a numerical integration program for several different situations. (Author)

A67-10893
SMALL SCALE LUNAR ROUGHNESS.
J. A. Bastin (London, University, Queen Mary College, London, England).
Nature, vol. 212, Oct. 8, 1966, p. 171-173. 7 refs.

Investigation of the small-scale roughness (centimeter and millimeter scale) of the lunar surface. The high degree of roughness of the surface was first detected by infrared measurements and has been confirmed by radar and millimeter-wave measurements, as well as by photographs from the U.S. and Soviet soft landings. The absence of horizontal directionality in the small-scale roughness observed in the photographs argues in favor of micrometeorites as the cause of the roughness. This is supported by the known distribution of meteorites with size. Since meteorites increase in number as their size decreases, the lunar surface should have many small craters of millimeter and centimeter dimensions and only a few much larger ones. This is the pattern that was actually observed. Micrometeorite bombardment rather than volcanic effects would thus appear to be the principal cause of the small-scale surface roughness. W.A.E.

A67-10904 #
STRATIFIED AND FACETED FORMS ON PANORAMAS OBTAINED FROM THE LUNA-9 SPACE STATION [SLOISTYE I GRANEVYE FORMY NA PANORAMAKH, POLUCHENNYKH SO STANTSII LUNA-9].
V. M. Vakhnin and G. I. Zmievskaia.
Akademiia Nauk SSSR, Doklady, vol. 170, Sept. 21, 1966, p. 560. In Russian.

Graphic interpretation of fragments from photographic panoramas of the lunar surface obtained by Luna 9. The straight-line boundaries between light and shadow observed on many of these photographs are typical only of faceted or flat-sided features of the relief. Stratified or "layered" structures are also observed, presenting a typical sawtooth profile. It is postulated that these forms are connected with the mineral composition of the lunar surface. W.A.E.

A67-10964
WHAT LUNA 9 TOLD US ABOUT THE MOON.
Iuri N. Lipskii (Moskovskii Gosudarstvennyi Universitet, Astronomicheskii Institut, Moscow, USSR).
Sky and Telescope, vol. 32, Nov. 1966, p. 257-260.

Interpretation of millimeter-sized features of the moon revealed by Luna-9 photographs. The steepness of the flight trajectories of the rocks photographed on the moon favors the idea that the rocks are fragments of dense subsurface strata, which were not exposed to lunar erosion before ejection. This idea can explain why the surfaces of many rocks differ in microstructure from the soil on which they rest. The circumstances of the Luna-9 soft landing provide other evidence of the strength of the lunar soil. Luna 9 has refuted the hypothesis of lunar dust. M.M.

A67-11123 *
AN OMNIDIRECTIONAL PENETROMETER FOR LUNAR SURFACE CHARACTERIZATION.
Richard G. McClellan and Robert S. Kraemer (Philco Corp., Aeronutronic Div., Newport Beach, Calif.).
IN: INSTRUMENT SOCIETY OF AMERICA, NATIONAL AEROSPACE INSTRUMENTATION SYMPOSIUM, 12TH, PHILADELPHIA, PA., MAY 2-4, 1966, PROCEEDINGS. [A67-11108 01-14]
Pittsburgh, Instrument Society of America, 1966, p. 127-136.
Contract No. NAS 1-4923.

A spherical, telemetering, omnidirectional penetrometer has been developed for the NASA Langley Research Center with a capability of transmitting acceleration vs time signatures during impact on soil-like materials. An extensive parametric impact research test effort has produced characteristic acceleration signatures for impacts at velocities of 20, 150, and 250 ft/sec; off-normal angles of 0, 30, and 60°; ambient pressures of 1 atm and 10^{-5} torr; penetrometer diameters of 4, 8.5, and 12 in.; and penetrometer weights of 2.2, 5, and 8 lb. Target materials included very low bearing strength flocculent material (Cabosil), basalt silt, a variety of sands, cellular foam, cobbles and pebbles, and a rigid steel plate. This report outlines the design and performance characteristics of the prototype penetrometer, describes impact test techniques, and summarizes the test results. (Author)

A67-11331 *
THE SYSTEM OF LUNAR CRATERS, QUADRANT IV.
D. W. G. Arthur, R. H. Pellicori, and C. A. Wood.
Research supported by NASA, Grant No. NsG-161-61.
COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 5. PART I (NUMBER 70).
Tuscon, University of Arizona Press, 1966. 220 p.

Listing of the designation, diameter, position, central peak information, and state of completeness for each discernible lunar crater with a diameter exceeding 3.5 km in the fourth lunar quadrant. Following the practice of the earlier parts, names have been given to large or conspicuous craters in the limb regions whenever such additions were considered necessary. The catalog contains about 8000 items and is illustrated by a map in 11 sections. M.M.

A67-11458
IMPLICATIONS OF THE NONUNIFORM COOLING BEHAVIOR OF THE ECLIPSED MOON.
R. F. Fudali (Bellcomm, Inc., Washington, D.C.).
Icarus, vol. 5, Sept. 1966, p. 536-544. 13 refs.

Development of a theory explaining the existence of areas the thermal behavior of which differs sharply from that of the surrounding lunar terrain. The probable explanation for this behavior is a difference in the insulating properties of the material exposed in these areas. Specifically, a lack of insulating debris over all or parts of the anomalous areas is conceptually sound and explains all the known facts. An analysis of the features and associations of these "hot spots" suggests that the debris is lacking because of simple downslope movement on high angle slopes. The necessity of high angle slopes to promote efficient removal of debris indicates that electrostatic particle transport is not significant on the moon and debris accumulations must be strongly dominated by local sources. Thus, if there are widespread debris deposits of substantial thickness on the moon, they must be characteristic of lunar continents rather than maria. The lack of debris on high angle slopes also suggests that the debris particles may be essentially noncohesive in the lunar environment. If this is true, the lunar deposits should approximate similar terrestrial deposits in density and strength. M.F.

A67-11459 *
LUNAR OVERLAY DEPTH IN MARE TRANQUILLITATUS, ALPHONSUS, AND NEARBY HIGHLANDS.
Leonard D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Icarus, vol. 5, Sept. 1966, p. 545-550. 9 refs.

Photographs of lunar craters obtained by the spacecraft Ranger 8 and Ranger 9 have been compared with those of laboratory craters overlain with known amounts of granular material. Results are consistent with the interpretation that at least 5 meters of granular material, and probably considerably more, have been deposited on Mare Tranquillitatus, Alphonsus, and nearby highland areas, subsequent to the formation of most of the craters 55 m in diameter or larger. This applies to both impact craters and those apparently of volcanic origin. The appearance of craters smaller than 30 m in diameter is consistent with less deposit of overlay subsequent to crater formation; hence these craters are believed to be newer. (Author)

A67-11460
NOTE ON THE NONUNIFORM COOLING BEHAVIOR OF THE ECLIPSED MOON.
D. F. Winter (Boeing Co., Scientific Research Laboratories, Geo-Astrophysics Laboratory, Seattle, Wash.).
Icarus, vol. 5, Sept. 1966, p. 551-553. 7 refs.

Proposal of an alternative not discussed by Fudali (1966) to account for the anomalous cooling of the moon's surface during lunar eclipses first observed by Saari and Shorthill. Bastin and Winter have suggested that preferential lunar surface roughness in the form of numerous cracks and declivities on a centimeter scale may explain the observed local nonuniformities in cooling rate during an eclipse. This explanation is elaborated on. M.F.

A67-11474
SHAPE OF THE MOON FROM THE ORBITER DETERMINATION OF ITS GRAVITATIONAL FIELD.
C. L. Goudas (Boeing Co., Scientific Research Laboratories, Seattle, Wash.), Z. Kopal (Manchester, University, Manchester, England), and Z. Kopal (Stanford University, Stanford, Calif.).
Nature, vol. 212, Oct. 15, 1966, p. 271. 5 refs.
Description of the principal features of the global shape of the moon, as deduced from Orbiter data, in terms of tesseral harmonics. A comparison with the results of previous harmonic analysis shows close correspondence. The equations are believed to support the theory that the mass of the moon is distributed homogeneously. They are also believed to contradict the possibility that the underlying deformations may constitute "frozen tides" caused by the attraction of the earth or any other body. The conclusion is drawn that the lunar globe possesses mechanical strength sufficient to sustain load differences amounting to at least 2.2 kilometers of surface material over large areas. S. Z.

A67-11567 #
POSSIBLE STRUCTURE OF THE SURFACE LAYER OF THE MOON [O VOZMOZHNOI STRUKTURE POVERKHNOSTNOGO SLOIA LUNY].
G. N. Dul'nev, Iu. P. Zarichniak, and B. L. Muratova (Leningradskii Institut Tochnoi Mekhaniki i Optiki, Leningrad, USSR).
Radiofizika, vol. 9, no. 5, 1966, p. 849-858. 10 refs. In Russian.
Derivation of an analytical expression for the effective thermal conductivity of bodies of various structures. The solution of the inverse problem - namely, the determination of the structure of a body from the effective coefficient of thermal conductivity - is considered. Conjectures are made concerning the possible structure of the surface layer of the moon on the basis of an analysis of radio-astronomy data concerning the value of the parameter $\gamma = (\lambda \rho c)^{-1/2}$ and certain other assumptions. A.B.K.

A67-11603 •
CROSS-POLARIZATION MEASUREMENTS AND THEIR RELATION TO TARGET SURFACE PROPERTIES.
K. Krishen, W. W. Koepsel (Kansas State University, Dept. of Electrical Engineering, Manhattan, Kan.), and S. H. Durrani (Radio Corporation of America, Astro-Electronics Div., RCA Space Center, Princeton, N.J.).
IEEE Transactions on Antennas and Propagation, vol. AP-14, Sept. 1966, p. 629-635. 10 refs.
Grant No. NsG-692; Contract No. NSR-17-004-003.
It has often been suggested in lunar studies that measurements of radar cross-polarization factor D should yield information on the target's surface roughness and dielectric properties. This paper describes an experimental effort to obtain quantitative data on $\langle D \rangle$, the average value of D, for randomly rough targets having Gaussian distribution of slopes. Bistatic X-band microwave measurements were conducted on targets with different dielectric constants but identical rough surfaces, and targets with same dielectric but different statistics. The dependence of $\langle D \rangle$ on various parameters is shown graphically, and extension to M.I.T. data of lunar cross-polarization is discussed. (Author)

A67-11700 *
ON THE TWO-LAYER MODEL OF THE LUNAR SURFACE.
Jack Copeland (Ewen Knight Corp., East Natick, Mass.).
Astrophysical Journal, vol. 146, Oct. 1966, p. 297-301. 9 refs.
Contract No. NASw-593.
Analysis of the two-layer model of the lunar surface with the assumption of an outer, relatively deep layer of porous material. The lunar surface is opaque to infrared radiation, but partially transparent to microwave radiation, so that measurements on microwave wavelengths give a weighted average temperature. The calculations are performed for two cases: (1) when the surface material is transparent to microwave radiation and serves only as a thermal blanket for the subsurface and (2) when the surface is partially transparent, to first-order terms, and serves as both a thermal blanket and a source of microwave flux. W.A.E.

A67-11857 #
PROTON-INDUCED HYDROXYL FORMATION ON THE LUNAR SURFACE.
E. J. Zeller, P. W. Levy (Brookhaven National Laboratory, Upton, N.Y.), and L. B. Ronca (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Bedford, Mass.).
Journal of Geophysical Research, vol. 71, Oct. 15, 1966, p. 4855-4860. 22 refs.
AEC Contract No. AT(11-1)-1057.
Experimental evidence for proton-induced OH formation on the linear surface by bombarding a glass, chemically similar in composition to common silicate minerals, with high-energy protons. The concentration of OH, before and after irradiation, was determined by infrared absorption measurements. The OH formation rate was greatest at the start of the bombardment and decreased with increasing dose. The maximum proton-to-OH conversion rate, at the start of the irradiation, is at least 5 or 10% and may be as high as 100%. Using this result, together with estimates of the lunar age and recent solar proton flux data, we were able to make very rough calculations of the minimum proton-induced OH content in the lunar surface. If mixing or churning is not important, the upper centimeter could contain 4×10^{16} OH per cm^3. When protons below 40 Mev and the higher conversion rate are included in the computation, the estimated OH concentrations could increase by a factor of 10 or more. If surface mixing or churning has occurred, they should be divided by an average churning depth. (Author)

A67-11858 • #
STUDY OF RADIO ECHOES FROM THE MOON AT 23 CENTIMETERS WAVELENGTH.
J. V. Evans and T. Hagfors (Massachusetts Institute of Technology, Lincoln Laboratory, Lexington, Mass.).
Journal of Geophysical Research, vol. 71, Oct. 15, 1966, p. 4871-4889. 53 refs.
Study of short-pulse radio reflections to determine the average scattering behavior of the lunar surface at a wavelength of 23 cm. The intensities of both the polarized (expected) and depolarized components of the return have been measured. A precise determination of the total radar cross section of the moon σ_0 using the Lincoln calibration sphere (LCS) satellite as a comparison standard yielded the results $\sigma_0 = 0.065 \pm 0.008$ times the physical cross section (πa^2). The observations reported here are compared with earlier measurements at 68- and 3.6-cm wavelength. It is concluded that, though the smoother parts of the moon's surface scatter in much the same fashion at 23-cm wavelength as at 68-cm wavelength, there appears to be an increase in the amount of surface covered with structure comparable in size to the wavelength. (Author)

A67-11860 • #
COMMENTS ON PAPER BY L. D. JAFFE, "DEPTH OF THE LUNAR DUST."
Evan Harris Walker (Miami, University, School of Environmental and Planetary Sciences, Coral Gables, Fla.).
Journal of Geophysical Research, vol. 71, Oct. 15, 1966, p. 5007-5010; Author's Reply, L. D. Jaffe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), p. 5011. 6 refs.
Grant No. NGR-10-007-011.
Discussion of a paper by Jaffe in which the interpretation of the appearance of the smaller craters in the Ranger 7 pictures as due to the presence of an overlay of dust has been studied. The methods used by Jaffe in studying the appearance of lunar craters are questioned and alternative interpretations of the apparent erosion of craters are suggested. M.F.

A67-12357 • #
THERMAL CONTROL FOR THE APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE (ALSEP).
D. Wiserman (NASA, Manned Spacecraft Center, Houston, Tex.) and D. Bitondo (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 16 p.

Discussion of the thermal control subsystem for the seven scientific experiments to be set up on the lunar surface by the Apollo astronauts. The thermal control subsystem will operate satisfactorily in the presence of lunar dust. The package is isolated from the widely varying thermal environment of the lunar surface in such a way that the primary mode of heat exchange is direct radiation from the thermal radiation plate to space. The system is totally passive to ensure reliability. A full-scale model of the subsystem has been tested under simulated conditions, and results are summarized. F. R. L.

A67-12414 * #
ADVANCED RESEARCH TELESCOPE FOR LUNAR SURFACE USE.
Leo H. Narodny, Harold Cohen (Kollsman Instrument Corp., Space Div., Syosset, N.Y.), and E. Ernest Wells (NASA, Marshall Space Flight Center, Huntsville, Ala.).
International Astronautical Federation, International Astronautical Congress, 17th, Madrid, Spain, Oct. 9-15, 1966, Paper. 16 p.

Investigation of the engineering, operational, and programing problems involved in conversion of the Goddard Experiment Package (GEP) into an optical astronomy package (OAP) for incorporation in the Lunar Module (LM) designed for unmanned landing and 28 man-day life support. The OAP consists of a 38-in. telescope, a spectrophotometer, a data-processing subsystem, analog electronics, and controls, plus other devices. It weighs 700 lb and requires 30 watts of power. The optical system employs a Richey Chrétien Cassegrainian configuration utilizing the largest beryllium optical primary mirror ever fabricated. The feasibility of modifying the GEP for inclusion in the LM is considered demonstrated, but merit studies remain to be completed. W.A.E.

A67-12492 #
PHOTOMETRY OF THE LIMB ZONE OF THE MOON [FOTOMETRIIA KRAEVOI ZONY LUNY].
N. P. Barabashov, O. I. Belobrova, V. I. Ezerskii, and V. A. Ezerskaia (Khar'kovskii Gosudarstvennyi Universitet, Astronomicheskaia Observatoriia, Kharkov, Ukrainian SSR).
Astronomicheskii Zhurnal, vol. 43, Sept.-Oct. 1966, p. 1039-1046. 24 refs. In Russian.

Study of the photometric features of the eastern and western limb zones of the lunar surface on the basis of a comparison with data for the photometric mean lunar surface. On the basis of this study, it is indicated that there may possibly be a difference in the structure of the microrelief of the two limb zones - namely, a somewhat denser state of the material in the outer cover in the eastern limb zone, including the region where the automatic station Luna 9 landed, as compared with regions located in the western limb zone. A. B. K.

A67-12493 #
COLOR CONTRASTS ON THE LUNAR SURFACE [O TSVETOVYKH KONTRASTAKH NA LUNNOI POVERKHNOSTI].
N. N. Evsiukov (Khar'kovskii Gosudarstvennyi Universitet, Kharkov, Ukrainian SSR).
Astronomicheskii Zhurnal, vol. 43, Sept.-Oct. 1966, p. 1047-1051. 7 refs. In Russian.

Derivation of a special color index for the lunar disk by applying the method of photographic photometry in the UV and IR spectral regions. In the case of most of the details the deviation of this color index from the mean for the moon is found to lie within the limits $\pm 0^m.25$, although there are a number of details with a much larger deviation, attaining $0^m.54$ in the case of Aristarchus. A. B. K.

A67-13049 *
DIRECTIONAL RADIATIVE CHARACTERISTICS OF CONICAL CAVITIES AND THEIR RELATION TO LUNAR PHENOMENA.
Leslie G. Polgar (NASA, Lewis Research Center, Cleveland, Ohio) and John R. Howell (NASA, Lewis Research Center, Fundamental Heat Transfer Branch, Cleveland, Ohio).
(American Institute of Aeronautics and Astronautics, Thermophysics Specialist Conference, 1st, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 13-15, 1965, Paper 65-669.)
IN: THERMOPHYSICS AND TEMPERATURE CONTROL OF SPACECRAFT AND ENTRY VEHICLES.
Edited by G. B. Heller.
New York, Academic Press, Inc. (Progress in Astronautics and Aeronautics. Volume 18), 1966, p. 311-323. 12 refs.
[For abstract see issue 21, page 3186, Accession no. A65-33346]

A67-13892
THE MOON'S SURFACE.
John Salisbury (USAF, Office of Aerospace Research, Cambridge Research Laboratories, Lunar-Planetary Research Branch, Bedford, Mass.).
Science Journal, vol. 2, Nov. 1966, p. 31-37.

Discussion of the nature of Surveyor 1 photographs of the lunar surface in support of the theories which claim that no mechanism exists on the moon for "sorting" different-sized particles into layers. Hence the hazards of lunar dust are believed to be minimal if not nonexistent. The main conclusions that can be drawn from the photographs are that the uppermost surface layer is not composed entirely of fine particles and that there is no blanketing or mantling of large blocks by finer debris. It is pointed out that the photographs may not be typical of the lunar surface as a whole, since the thermal behavior of the lunar surface indicates that the surface material is not everywhere the same. S. Z.

A67-13934 #
DUST ON THE MOON'S SURFACE?
Heinz H. Lettau (Wisconsin, University, Dept. of Meteorology, Madison, Wis.).
Journal of Geophysical Research, vol. 71, Nov. 15, 1966, p. 5469, 5470.

Discussion of the problem of determining the nature of the lunar surface. The interpretations of the Luna 9 photographs by Jaffe and by Kuiper are examined. The author points out that these experts based their conclusions solely on visual impressions from photographs. It is noted that significant information on the physical structure of the lunar surface has been derived from measurements of thermal radiation at various wavelengths - e.g., Kopal (1960) and Shorthill (1962). The author's interpretation is that the lunar crust is most likely porous rather than covered by dust. M.F.

A67-13936 * #
DISCUSSION OF PAPER BY J. A. O'KEEFE AND E. W. ADAMS, "TEKTITE STRUCTURE AND LUNAR ASH FLOWS."
Kenzo Yagi (Hokkaido University, Dept. of Geology and Mineralogy, Sapporo, Japan).
Journal of Geophysical Research, vol. 71, Nov. 15, 1966, p. 5492, 5493; Author's Reply, J. A. O'Keefe and P. D. Lowman (NASA, Goddard Space Flight Center, Laboratory for Theoretical Studies, Greenbelt, Md.), p. 5494. 10 refs.

Evaluation of theoretical calculations on the pressure, temperature, and voidage of ash flows both on the earth and moon. It is decided that if ash flows are formed on the surface of the moon, the acidic parent materials of such flows would have been derived from the basaltic magma solely through crystallization differentiation without any contamination of siliceous sediments, which are entirely absent on the moon. Therefore, they should be similar in chemical composition to an acid differentiate of some basaltic intrusions. B. B.

A67-14133 * #
APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE.

Clyde R. Murtaugh (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).
American Institute of Aeronautics and Astronautics, Annual Meeting, 3rd, Boston, Mass., Nov. 29-Dec. 2, 1966, Paper 66-919. 5 p.
Members, $0.75; nonmembers, $1.50.
Contract No. NAS 9-5829.

Review of a lunar surface experiment program to be carried out with the use of the Apollo package of scientific instruments and supporting subsystems. Operation of this equipment includes manned and unmanned activities, involving basic scientific tasks of surface assessment and sample collection, and the deployment of instruments to operate for one year after departure of the spacecraft. Provisions are being made for the following long-term experiments: passive seismic, active seismic, magnetometer, solar wind spectrometer, suprathermal ion detector, heat flow, and charged-particle lunar environment. S. Z.

A67-14308

HUMANIZING A MOON ROVER.
Joseph L. Seminara (Lockheed Aircraft Corp., Lockheed Missiles and Space Co., Sunnyvale, Calif.).
Machine Design, vol. 38, Nov. 24, 1966, p. 124-128.

Discussion of the local scientific survey module (LSSM), a small lunar vehicle designed to provide two astronauts with transportation and a portable scientific lab on the lunar surface. This concept is one of several being studied for exploration of the moon after the first Apollo landings. The LSSM would be delivered to the lunar surface along with a LEM (lunar excursion module) shelter in one unmanned package. The two machines would then be alone on the surface for up to 90 days, until the arrival of the two crew members. The astronauts would descend to the moon in a LEM shuttle to occupy the shelter, which would serve as a fixed base and provide habitable living quarters. The LSSM would be used for daily exploration sorties of 3 to 6 hr. At the end of 14 days, the crew would start their journey home by lifting off the moon in the LEM shuttle to the orbiting Apollo Command Module. M.M.

A67-14555 #

PROPELLANT SUPPLY AT EXTRATERRESTRIAL BASES ON THE MOON AND PLANETS [TREIBSTOFFVERSORGUNG AUF AUSSERIRDISCHEN MOND- UND PLANETENSTÜTZPUNKTEN].
E. W. Schmidt (Deutsche Versuchsanstalt für Luft- und Raumfahrt, Institut für Raketentreibstoffe, Stuttgart, West Germany).
Wissenschaftliche Gesellschaft für Luft- und Raumfahrt and Deutsche Gesellschaft für Raketentechnik und Raumfahrt, Jahrestagung 1966, Bad Godesberg, West Germany, Oct. 4-8, 1966, Paper. 12 p.
6 refs. In German.

Consideration of the structure and composition of the moon and planets' crust as determined by Luna-9, Surveyor-1, and Mariner-4 photographs, as a conceivable economical-source of fuel for interplanetary manned traffic. Lack of information on water content in lunar rock is the principal obstacle in the evaluation of lunar fuel resources. It is believed, however, that for a certain large number of launchings propellant preparation from extraterrestrial materials, rather than transportation from the earth, will be preferable. Rocket fuel production under extraterrestrial conditions is discussed. V.Z.

A67-14735

THREE-COLOR PHOTOELECTRIC PHOTOMETRY OF THE MOON.
Geraint L. Roberts (Manchester, University, Dept. of Astronomy, Manchester, England).
Icarus, vol. 5, Nov. 1966, p. 555-564. 18 refs.
Grant No. AF EOAR 64-72; Contract No. AF 61(052)-882.

Preliminary results are described of a program of detailed high-resolution lunar photoelectric photometry. A three-beam photoelectric photometer designed specifically for lunar colorimetric studies is described briefly. Experiments designed to measure short time variations in lunar luminescence gave negative results. This is attributed to lack of solar activity. Photoelectric measurements during the lunar eclipse of June 25, 1964 at wavelengths λ 5450 Å, λ 6714 Å, and λ 7889 Å are discussed. It is proposed to produce detailed color index contour maps of the moon. (Author)

A67-14739

A STOCHASTIC MODEL OF THE FORMATION AND SURVIVAL OF LUNAR CRATERS. V.
Allan H. Marcus (Case Institute of Technology, Cleveland, Ohio; Cambridge, University, Cambridge, England).
Icarus, vol. 5, Nov. 1966, p. 590-605. 18 refs.

Approximate upper and lower bounds are obtained for the expected number density of lunar craters by means of a model which takes into account the formation of primary and secondary craters and the destruction of craters by obliteration and filling. Some numerical examples considered are relevant to primary and secondary craters formed by meteoroidal impacts. Predicted number densities are compared with crater-diameter distributions from photographs taken by the Ranger 7 spacecraft. The shape of the observed distribution is the same as that of the predicted distribution, but the observed density of small craters is about 15 times larger than that predicted by analogy with terrestrial explosion craters. If the observed excess is real, then either some primary craters produce an unusually large number of secondaries, or else many of the smaller lunar craters are of internal origin. The excess may be explained in part by incompleteness of secondary crater counts for terrestrial explosion craters upon which the model functions are based. (Author)

A67-14740 *

MODELS OF THE LUNAR SURFACE INCLUDING TEMPERATURE-DEPENDENT THERMAL PROPERTIES.
Jeffrey L. Linsky (Harvard University, Harvard College Observatory, Cambridge, Mass.).
Icarus, vol. 5, Nov. 1966, p. 606-634. 61 refs.
Grant No. NsG-64-60.

The thermal conditions in the lunar surface are considered on a gross scale in terms of models with temperature-dependent thermal properties, including radiative energy transport. Agreement is obtained with infrared measurements of cold terminator temperatures and radio lunation data at millimeter wavelengths for a range of postulated parameters of the surface material. The observed increase of mean radio brightness temperature with wavelength is interpreted as due to radiative energy transport and the resultant nonlinearity of the heat-conduction equation, rather than to a large radioactive heat flux. The postulated existence of radiative energy transport is consistent with a porous or frothy medium, in agreement with photometric and laboratory simulation experiments, as well as with recent radar depolarization measurements. A distance scale of 0.1 to 0.3 mm for the effective mean separation of radiating surfaces is suggested by this interpretation of the data. (Author)

A67-14741

INFRARED AND VISIBLE IMAGES OF THE ECLIPSED MOON OF DECEMBER 19, 1964.
J. M. Saari, R. W. Shorthill, and T. K. Deaton (Boeing Co., Scientific Research Laboratories, Seattle, Wash.).
Icarus, vol. 5, Nov. 1966, p. 635-659. 10 refs.
Contract No. AF 19(628)-4371.

The moon was scanned with 10'' resolution at 0.45 and 10 to 12 μ during the total lunar eclipse of Dec. 19, 1964. It was found that the lunar surface exhibits a surprising amount of thermal inhomogeneity. Hundreds of thermal anomalies were observed, most of which can be identified with bright craters or white areas. Certain maria and portions of maria were found to be thermally enhanced over their environs during the eclipse. The analog signals recorded on magnetic tape were used to make visible and infrared images from the scan data. (Author)

A67-15064

LUNAR GEOLOGICAL RESEARCH [RECHERCHE GEOLOGIQUE LUNAIRE].

J. H. Focas and A. Dollfus (Centre National de la Recherche Scientifique, Service d'Aéronomie, Observatoire de Meudon, Meudon, Seine-et-Oise, France).
IN: RESEARCH IN GEOSCIENCES AND ASTRONOMY; PROCEEDINGS OF THE FIRST LUNAR INTERNATIONAL LABORATORY SYMPOSIUM, ATHENS, GREECE, SEPTEMBER 16, 1965. [A67-15062 04-11]
Edited by F. J. Malina.
Vienna, Springer-Verlag, 1966, p. 20-27. 24 refs. In French.

Discussion of the present state of knowledge of lunar geology and of the probable state of knowledge of this subject at the beginning of a Lunar International Laboratory (LIL) program. The available data on the thermal and optical properties of the lunar soil are summarized. An attempt is made to predict the state of knowledge of the morphology of the lunar surface and the origin of its geological formations at the beginning of an LIL program. The morphological characteristics of certain terrestrial formations are compared with those of the lunar formations photographed by spacecraft, in order to furnish a basis for geological classification of the lunar formations. The nature of the geological research to be carried out on the moon after the LIL has been set up on the lunar surface is specified.
A. B. K.

A67-15065

A LUNAR PHYSICS PROGRAM FOR A LUNAR INTERNATIONAL LABORATORY [SUR UN PROGRAMME DE SELENOPHYSIQUE POUR UN LABORATOIRE LUNAIRE INTERNATIONAL].
Georges Jobert (Paris, Université, Institut de Physique du Globe, Paris, France).
IN: RESEARCH IN GEOSCIENCES AND ASTRONOMY; PROCEEDINGS OF THE FIRST LUNAR INTERNATIONAL LABORATORY SYMPOSIUM, ATHENS, GREECE, SEPTEMBER 16, 1965. [A67-15062 04-11]
Edited by F. J. Malina.
Vienna, Springer-Verlag, 1966, p. 28-34. In French.

Development of a program of exploration of the lunar surface to be carried out by a Lunar International Laboratory. It is assumed that the most effective method of determining the lunar structure will be seismology, either using automatically functioning stations or by carrying out seismic explosions. Certain difficulties in determining the response of the moon to solar and terrestrial tidal forces by means of gravimeters and inclinometers and in measuring the thermal flux against a background of large variations in the surface temperature are pointed out. It is believed that it may be possible to carry out magnetic measurements, in spite of the probable absence of a planetary magnetic field (although in the absence of an actual magnetosphere, it is thought very unlikely that the magnetotelluric method can be used). Electrical methods are believed to be applicable under conditions which may be analogous to those encountered in terrestrial deserts.
A. B. K.

A67-15177 #

ACCURACY OF LUNAR RELATIVE HEIGHT VALUES - NEW VALUES FOR 163 POINTS [DIE GENAUIGKEIT DER ANGABEN VON RELATIVEN HÖHEN AUF DEM MONDE - NEUE WERTE FÜR 163 PUNKTE].
Josef Hopmann.
Österreichische Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Klasse, Sitzungsberichte, Abteilung 2, vol. 174, no. 1-4, 1965, p. 57-84. 20 refs. In German.

Micrometric determination of the absolute and relative heights of 163 unobtrusive points (small hills and ridges) on the moon. The values obtained for these points are tabulated and discussed with respect to their accuracy in comparison to the values obtained by Mädler, Schmidt, and the U.S. Army Map Service. It is seen that the accuracy of the relative heights is roughly ± 0.25 km for each of the sources studied. Visual micrometer measurements appear to be slightly superior to photographic data. However, data obtained from illumination (extinction) of peaks beyond the terminator are also fairly accurate. The unreliability of the determination of the coordinates of a point is found to contribute greatly to the mean error of height measurements.
V. P.

A67-16051 #

STUDY OF LUNAR X-RAY EMISSION WITH THE AID OF THE LUNAR ORBITER LUNA 10 [ISSLEDOVANIIA RENTGENOVSKOGO IZLUCHENIIA LUNY S POMOSHCH'IU SPUTNIKA LUNY "LUNA-10"].
S. L. Mandel'shtam, I. P. Tindo, and V. I. Karev.
Kosmicheskie Issledovaniia, vol. 4, Nov.-Dec. 1966, p. 827-837. 12 refs. In Russian.

Calculation of the intensity of the characteristic spectral lines of Si, Al, and Mg of lunar surface rock, made fluorescent by solar X rays. The Luna 10 equipment for the detection of lunar X-ray emission is described. Measured results are given for the cosmic radiation background in the vicinity of the moon, for terrestrial magnetosphere electrons of energies above 40 kev, and for lunar X-ray emission.
V. Z.

A67-16053 #

STUDY OF CORPUSCULAR RADIATION BY THE LUNA 10 SPACE VEHICLE [IZUCHENIE KORPUSKULIARNOI RADIATSII NA KOSMICHESKOM APPARATE "LUNA-10"].
N. L. Grigorov, V. L. Maduev, N. F. Pisarenko, and I. A. Savenko.
Kosmicheskie Issledovaniia, vol. 4, Nov.-Dec. 1966, p. 842-850. 5 refs.
In Russian.

Results of corpuscular radiation measurements with devices on board the Luna 10 orbiter. The intensity of primary cosmic radiation in interplanetary space, the albedo of the lunar surface, and soft particle fluxes in the tail of the terrestrial magnetosphere are measured. The measuring technique is described, and tabulated and plotted data are given.
V. Z.

A67-16154

RESULTS FROM LUNAR ORBITER 2.
Sky and Telescope, vol. 33, Jan. 1967, p. 22-26.

Discussion of some results of the photographic reconnaissance of the moon by Lunar Orbiter 2 to determine possible landing sites for the Apollo mission. Several views of some of the potential landing sites are given, and the launch, space flight, and injection of the Luna 2 into a moon orbit is described. Details of the photographic facility are outlined, and some oblique views of the crater Copernicus are evaluated.
B. B.

A67-16155

COLOR EVENTS ON THE MOON.
Patrick Moore (Armagh Observatory, Armagh, Northern Ireland).
Sky and Telescope, vol. 33, Jan. 1967, p. 27.

Brief description of the British moon-blink program with emphasis on the observations of the crater Gassendi on Apr. 30 and May 1, 1966. The moon is viewed directly through an eyepiece instead of with an image tube; the blink device consists of a filter wheel carrying 120° sectors of red and blue gelatin filters, and a clear space.
B. B.

A67-16463 •

INSTRUMENT FOR LUNAR SURFACE CHEMICAL ANALYSIS.
Anthony Turkevich, Karlfried Knolle (Chicago, University, Enrico Fermi Institute for Nuclear Studies and Dept. of Chemistry, Chicago, Ill.), Richard A. Emmert, Wayne A. Anderson (Chicago, University, Enrico Fermi Institute for Nuclear Studies, Laboratory for Astrophysics and Space Research, Chicago, Ill.), James H. Patterson (Argonne National Laboratory, Chemistry Div., Argonne, Ill.), and Ernest Franzgrote (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).
Review of Scientific Instruments, vol. 37, Dec. 1966, p. 1681-1686. 10 refs.
AEC-supported research; Grant No. NsG-127-61; Contracts No. JPL-950750; No. JPL-950315.

An instrument has been designed and constructed which utilizes the interactions of monoenergetic alpha particles with matter for surface chemical analysis. The source of alpha particles is a radioactive nuclide, such as ^{242}Cm. The energy spectra of back-scattered alpha particles are measured with semiconductor detectors. Other detectors (with gold foils over them to eliminate alpha

particles) register protons from α, p reactions. Transistorized electronics provide 128-channel pulse height analyzers for both alpha and proton spectra. The first prototype instrument designed for the presently planned Surveyor lunar missions weighs less than 4 kg and uses less than 1.3 watts. (Author)

A67-16545

ELEMENTAL ANALYSIS USING NEUTRON INELASTIC SCATTERING.

James A. Waggoner and Richard J. Knox (California, University, Lawrence Radiation Laboratory, Livermore, Calif.).

IN: RADIOISOTOPES FOR AEROSPACE; PROCEEDINGS OF THE FIRST SYMPOSIUM ON RADIOISOTOPE APPLICATIONS IN AEROSPACE, DAYTON, OHIO, FEBRUARY 15-17, 1966. PART 2 - SYSTEMS AND APPLICATIONS. [A67-16526 05-22]

Symposium sponsored by the U.S. Air Force, the U.S. Atomic Energy Commission, and the Instrument Society of America.

Edited by J. C. Dempsey and Paul Polishuk.

New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 270-291. 7 refs.

The technique of elemental analysis by analysis of the γ rays resulting from the inelastic scattering of 14-Mev neutrons is described. This method is especially suitable for analysis of the major constituents of bulk samples such as planetary surfaces. Sample size, limits of sensitivity for Fe, Si, O, Mg, Al, Na, K, and Ca, detector resolution, shielding requirements, and geometrical effects are considered. An instrument designed for planetary surface analysis will be described as one possible application of this method. This instrument weighs about 15 lb and includes a pulsed source of 14-Mev neutrons, a γ-ray detector, and a 256-channel pulse height analyzer as well as the necessary electronics. (Author)

A67-16546 *

LUNAR AND PLANETARY SURFACE ANALYSIS USING NEUTRON ACTIVATION.

M. Y. Cuypers, J. S. Hislop, W. E. Kuykendall, and R. E. Wainerdi (Texas Agricultural and Mechanical University, College Station, Tex.).

IN: RADIOISOTOPES FOR AEROSPACE; PROCEEDINGS OF THE FIRST SYMPOSIUM ON RADIOISOTOPE APPLICATIONS IN AEROSPACE, DAYTON, OHIO, FEBRUARY 15-17, 1966. PART 2 - SYSTEMS AND APPLICATIONS. [A67-16526 05-22]

Symposium sponsored by the U.S. Air Force, the U.S. Atomic Energy Commission, and the Instrument Society of America.

Edited by J. C. Dempsey and Paul Polishuk.

New York, Plenum Press, Division of Plenum Publishing Corp., 1966, p. 292-308. 9 refs.

Grant No. NsG-239-62.

The 14-Mev neutron activation analysis (NAA) technique has been used for the determination of silicon, iron, aluminum, magnesium and oxygen in granites and basalts. A prototype system for lunar surface analysis has been developed and utilized to investigate the feasibility of the technique. The principle of operation involved the use of a rotating assembly for alternately positioning the neutron generator and the γ-ray detector directly above the surface to be analyzed. Results are based on the analyses of decay curves and γ-ray spectra obtained by multiple counting of irradiated samples. (Author)

A67-16575 *

DETERMINATION OF THE MASSES OF THE MOON AND VENUS, AND THE ASTRONOMICAL UNIT FROM THE RADIO TRACKING OF MARINER II.

John D. Anderson and Michael R. Warner (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.).

IN: TRAJECTORIES OF ARTIFICIAL CELESTIAL BODIES; COSPAR, INTERNATIONAL ASTRONOMICAL UNION, AND INTERNATIONAL UNION OF THEORETICAL AND APPLIED MECHANICS, SYMPOSIUM, PARIS, FRANCE, APRIL 20-23, 1965, PROCEEDINGS. [A67-16554 05-30]

Edited by Jean Kovalevsky.

Berlin, Springer-Verlag, 1966, p. 216-246. 14 refs.

Description of the use of Doppler data from the Mariner 2 space probe to Venus to obtain independent determinations of the masses of the moon and Venus and the astronomical unit. A number of sources of systematic error are investigated. Particularly emphasized are the uncertainties in the ephemerides of the earth and Venus and the contribution of low-thrust forces from the attitude-control system. The inclusion of these effects, together with an improvement in the computation of the Mariner 2 orbit in the vicinity of Venus, results in more reliable values for the constants than those previously published. The earth-to-moon mass ratio is unchanged and is consistent with a value of 81.30. A value of 408,600 for the reciprocal mass of Venus satisfies the improved determination. Finally, a provisional value of the astronomical unit is in agreement with other radar determinations. S.Z.

A67-16578 #

A SURVEY OF DARK LUNAR RADIAL BANDS.

W. J. Leatherbarrow.

British Astronomical Association, Journal, vol. 77, Dec. 1966, p. 33-36.

Complement to the classification of banded craters established by Abineri and Lenham by the addition of a new class (Kunowsky). Craters in this class have extremely large and extremely dark floors. Under no conditions of light was it possible to see shadow prolongations in any craters of this type. It is concluded that when a band traverses an unusually dark floor it does not show the shadow prolongation and may therefore be assumed not to lie in a valley-like depression. Some comments are made on the distribution of banded craters, bands in Prosper Henry, and the nature of radial bands. F.R.L.

A67-16594 #

TRANSIENT CHANGES ON THE MOON.

Barbara M. Middlehurst (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

The Observatory, vol. 86, Dec. 1966, p. 239-242. 15 refs.

NSF Grant No. GP-5940.

Analysis of the statistics of about 200 events concerning transient changes of the moon, which have occurred in the 18th, 19th, and 20th centuries, from the following points of view: (1) type of event, (2) lunar phase, (3) relative frequency and duration, (4) correlation with solar activity, (5) position in the lunar orbit, (6) position of the sites of the events on the surface of the moon. Bright spots in color changes which occur on the dark side of the moon as well as on the illuminated part and which involve areas of the order of few kilometers in diameter are considered, together with reports of obscurations. S.Z.

A67-16612

TRAFFICABILITY OF THE LUNAR SURFACE CONSIDERING THE BEARING CAPACITY AND FAILURE MODES OF LUNAR SURFACE MATERIALS.

John D. Peters (U.S. Armed Forces Industrial College, Fort Leslie J. McNair, Washington, D.C.).

IN: SPACE AGE FACILITIES; AMERICAN SOCIETY OF CIVIL ENGINEERS, AERO-SPACE TRANSPORT DIVISION, SPECIALTY CONFERENCE, COCOA BEACH, FLA., NOVEMBER 17-19, 1965, PROCEEDINGS. [A67-16606 05-11]

New York, American Society of Civil Engineers, 1966, p. 163-201. 20 refs.

Evaluation of the characteristics of the lunar surface to determine its ability to carry traffic. A model of the lunar surface is devised, and strength and failure modes of the surface material are considered. The landing system design of the Apollo program's Lunar Excursion Module and its suitability to the lunar surface is discussed, and designs of the lunar landing and tractive systems are studied. B.B.

A67-16714 #

INTERPRETATION OF RANGER VII RECORDS.

Gerard P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

(JPL Technical Report No. 32-700, Feb. 10, 1965, p. 9-73.)

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 4 (Numbers 58-59).

Tucson, University of Arizona Press, 1966, p. 1-70. 22 refs.

Interpretation of Ranger VII photographs and assessment of their impact on lunar science. The lunar maria are classified on the basis of their gross structure as found from earth-based photography. A study of the vertical structure of maria in general at the intermediate scale is made, and results on the presence or absence of a cosmic dust layer are given. The important data yielded on lunar craters and crater rays are reviewed, and clues to the morphology of the ridges in the maria are discussed, together with the mechanical structure of the upper layers of the mare floor. Ranger records have shown a new class of objects - shallow depressions and dimple craters. They have no rims, and the outer portions are identical in that their shape approximates an inverted Gaussian curve, rotated around its vertical axis. M.M.

A67-16715 #

FURTHER OBSERVATIONS ON THE RANGER VII RECORDS.

Ewen A. Whitaker.

(JPL Technical Report No. 32-700, Feb. 10, 1965, p. 149-154.)

IN: COMMUNICATIONS OF THE LUNAR AND PLANETARY LABORATORY. VOLUME 4 (Numbers 58-59).

Tucson, University of Arizona Press, 1966, p. 71-76.

Discussion of evidence provided by Ranger VII records in support of the theory that the lunar maria were originally formed by processes involving the flow of material rather than by gradual dust transport or sudden deposition of shattered surface materials resulting from very large impacts. It is concluded that (1) smooth conical lunar craters are presumably formed by impacting solid meteoritic bodies; (2) the larger ray systems appear to be more readily explainable on the basis of impacts with cometary nuclei, the ray crater is assumed to be formed by the impact of the main nucleus, the rays are assumed to be thin deposits of cometary dust, fanned radially by the expanding gas and vapor dome produced by the vaporized ices; (3) the ray material is evenly distributed and has not been deposited in discrete clumps, and the general dimness of the Mare Cognitum rays, as compared with bright rays, suggests that nowhere do these rays completely blanket the mare surface material; and (4) the shallow, round or elongated, soft-edged depressions seen in some of the ray elements are believed to have no

A67-17083

THE SURFACE OF THE MOON.

G. P. Kuiper (Arizona, University, Lunar and Planetary Laboratory, Tucson, Ariz.).

IN: INTERNATIONAL ASTRONOMICAL UNION, GENERAL ASSEMBLY, 12TH, HAMBURG, WEST GERMANY, AUGUST 25-SEPTEMBER 3, 1964, PROCEEDINGS. [A67-17068 05-30]

Edited by J.-C. Pecker.

London, Academic Press, Ltd. (International Astronomical Union, Transactions. Volume 12B), 1966, p. 658-662. 6 refs.

Brief review of some of the scientific results and tentative explanations of the surface of the moon which have been arrived at from a subjective interpretation of two Ranger 7 atlases and the Experimenters' Report. The color study has shown that the moon is not covered with a layer of cosmic dust which would have obliterated the color differences, and that any migration of a hypothetical layer of lunar dust is restricted to subtelescopic dimensions because the color provinces observed have extremely sharp boundaries. The conclusion has been reached that the flows observed on the lunar maria were originally covered by a layer roughly 10-m-thick of extremely vesicular rock, with a bulk density of 0.1 to 0.3, and a bearing strength of the order of 1 to 10 kg/cm^2. Below this surface layer, there is expected to be a denser rock which resulted from solidification of the very fluid magma responsible for the bulk of the flow. (Author)

A67-17084

INTERPRETATION OF THE SMALL CRATERS OF THE MOON'S SURFACE REVEALED BY RANGER VII.

E. M. Shoemaker (U.S. Geological Survey, Flagstaff, Ariz.).

IN: INTERNATIONAL ASTRONOMICAL UNION, GENERAL ASSEMBLY, 12TH, HAMBURG, WEST GERMANY, AUGUST 25-SEPTEMBER 3, 1964, PROCEEDINGS. [A67-17068 05-30]

Edited by J.-C. Pecker.

London, Academic Press, Ltd. (International Astronomical Union, Transactions. Volume 12B), 1966, p. 662-672. 7 refs.

Interpretation of small lunar craters revealed by Ranger 7 photographs of Mare Cognitum. The craters observed are classified by size into categories of primary craters, secondary craters, and craters less than 300 m in diameter. Primary craters on the lunar maria are interpreted as having been formed by impact of meteoroids and larger interplanetary objects, such as asteroids and comet nuclei, while secondary craters are interpreted as having been formed by impact of comparatively low-velocity fragments of the moon ejected from primary craters located both on the maria and on other parts of the lunar surface. It is concluded that the rays on Mare Cognitum consist primarily of mare material ejected from the secondary craters but contain a small admixture of material derived from the more distant primary crater with which the rays are associated. The size-frequency distributions of primary and secondary craters on the lunar maria are estimated, taking into account the effects of interaction among small craters. A.B.K.

A67-17202 *

LUNAR RING DIKES FROM LUNAR ORBITER I.

John A. O'Keefe, Paul D. Lowman, Jr., and Winifred S. Cameron (NASA, Goddard Space Flight Center, Greenbelt, Md.).

Science, vol. 155, Jan. 6, 1967, p. 77-79. 16 refs.

Orbiter photographs of the wall of a large circular formation on the moon show that the wall is a convex body resembling a flow of viscous lava. The slopes are less than the angle of repose of dry rock; hence an explanation in terms of mass wastage is hard to support. The viscosity is approximately 10^{13} centimeter-gram-second units, indicating an acid lava. (Author)

A67-17293 #

THE SIZE DISTRIBUTION OF LUNAR CRATERS.

C. A. Cross.

Royal Astronomical Society, Monthly Notices, vol. 134, no. 3, 1966, p. 245-252. 10 refs.

Use of a total of 1600 measurements ranging from 0.65 to 69,000 m of all the readily visible crater diameters on Ranger 7, 8, and 9 pictures to establish the size distribution of craters on three areas of the moon. The results show that in all three areas the frequency of crater occurrence is inversely proportional to the square of the crater diameter and that this relation holds accurately over the whole size range. The overall crater frequency is shown to be lowest in the Mare Tranquillitatis, 1.4 times higher in the Mare Nubium, and 2.5 times greater in the Alphonsus region. The consequences of extrapolating this distribution law to still larger and smaller structures is briefly examined. M.F.

A67-17295 #

COMMENTS ON "DISTRIBUTION OF CRATERS ON THE LUNAR SURFACE."

Allan Marcus (Cambridge, University, Statistical Laboratory, Cambridge, England).

Royal Astronomical Society, Monthly Notices, vol. 134, no. 3, 1966, p. 269-274. 8 refs.

Examination of a recent empirical study by Fielder (1965) on the diameter frequency, distribution of centers, and distribution of number density of lunar craters. His results are compared with certain theoretical studies by the author. It is found that the cumulative number of craters larger than diameter Δ follows an inverse power law $C\Delta^{-s}$ with index $s = 2.0$, for craters larger than 30 km in diameter; this suggests that the original distribution of crater diameter is an inverse power law with index greater than 2. Available crater statistics neither preclude nor establish the impact of volcanic hypothesis for the origin of craters. M.F.

A67-17386 #

SOLAR PROTON ACTIVATION OF THE LUNAR SURFACE.

D. B. Ebeoglu and K. M. Wainio (Bendix Corp., Bendix Systems Div., Ann Arbor, Mich.).

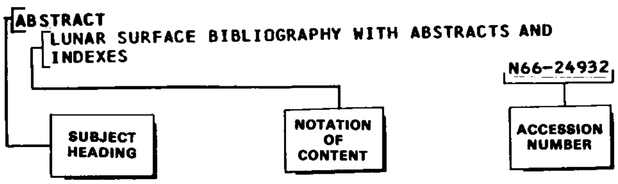
Journal of Geophysical Research, vol. 71, Dec. 15, 1966, p. 5863-5872. 13 refs.

The nuclear activation on the surface of the moon due to solar protons has been estimated. Proton and neutron fluxes and the production rate of radionuclides have been calculated as a function of depth, and comparisons have been made between several models of the lunar crust. The purpose of the calculations has been to evaluate the effectiveness of lunar material as a radiation shield and also to predict the particle flux reflected from the surface. The build-up of Mn 54, Na 22, C 14, and Be 7 is given in compositions representing both the volcanic and meteoritic-impact hypotheses for the lunar surface. The effect of the angular distribution of the protons on the radionuclide production rate and particle fluxes has also been investigated. Examples involving a monoenergetic beam of 400-Mev protons as well as a solar proton spectrum are included, permitting direct comparisons with experimental irradiations of similar targets. The results show that the activation is strongly dependent on the spectrum and angular distribution of incident protons but relatively insensitive to the composition. (Author)

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